ACCURACY OF RESPONDING IN EXTINCTION FOLLOWING ERRORLESS DISCRIMINATION TRAINING WITH CONTINUOUS AND INTERMITTENT REINFORCEMENT

By

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To Peggy

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The effects of continuous and intermittent reinforcement on the maintenance of accuracy in extinction of a discrimination taught with errorless discrimination procedures in trial conditions were investigated in a functional analysis of responding by four Black kindergarten boys on alphabet letter discriminations. This study was based on an experiment by Terrace (1970) in which he found increased error responses in extinction by subjects who had been trained with errorless procedures and continuous reinforcement in trial conditions.

A within-subject design was employed in the present study. The experimenter taught subjects individually in daily one-to-one sessions over a six-week period. Subjects were taught to name one letter in each of two letter pairs

during an acquisition phase. Letter pairs were "b-d" and "P-R." Letters were printed individually on cards which were shown to subjects in random sequence in timed sessions by means of a handmade apparatus. During the first training session, the letter not to be named was initially different from the one to be named in size, shade, and time of exposure. It was gradually changed (faded) on successive trials throughout the session until it was different from the other only in its distinctive shape. Marbles redeemable for pennies were delivered for correct responses. An error occurred if a subject made any naming response to the inappropriate letter. One letter pair was maintained on a schedule of continuous reinforcement and the other was gradually switched to an intermittent schedule during a maintenance phase. During extinction, reinforcement was withheld.

The basic datum in this study was frequency of responding. Frequencies for correct responses and errors were recorded daily on the Standard Behavior Chart. Celerations, or trend lines reflecting changes in frequency over time, were calculated from frequencies for correct responses and errors in each phase. Overall accuracy was obtained in each phase by an improvement index, an expression of the

ratio of celerations for correct responses and errors. Grouped data was expressed by geometric means of celerations and improvement indices for the four subjects.

Results of this study were not consistent with those of Terrace's (1970) experiment, and failed to reveal any noticeable difference in the degree to which accuracy of a discrimination was maintained in extinction following errorless discrimination training with continuous and intermittent reinforcement for the four subjects used in this study. Frequency of correct responding was only slightly lower during extinction when compared to the maintenance phase for both schedules. Comparison of error trends between the maintenance and extinction phases revealed an increase in errors during the latter, for both reinforcement conditions, with the values of the trends identical. Subjects displayed much "emotional," or "frustration," behavior during extinction.

It was suggested that the results of this study demonstrated the efficacy of errorless procedures in discrimination training as well as the pitfalls of *a priori* assumptions concerning the relevancy of experimenter-selected methods and materials. The results did not

justify any statement relative to the superiority of one reinforcement schedule over the other in errorless discrimination training in trial procedures.

CHAPTER I

PURPOSE OF THE STUDY

The purpose of this study is to investigate the effects of continuous and intermittent reinforcement on the maintenance of a discrimination taught using errorless discrimination procedures in trial conditions. Schedule effects are to be assessed by a functional analysis of accuracy of responding during a maintenance phase and an extinction phase following errorless training of letter discriminations with kindergarten pupils.

Errorless discrimination training procedures have been extensively investigated in infrahuman studies by Terrace (1966; 1971) and others. Recently a number of researchers have attempted to adapt these procedures in studies with normal and retarded children.

The impetus for this study derived from a finding by Terrace (1970) that the reinforcement schedule used in certain training conditions had a significant effect on the stability of a discrimination during extinction. Accuracy of responding by a group of subjects trained

in trial conditions using continuous reinforcement was seriously disrupted during extinction. Another group, trained with intermittent reinforcement, maintained accuracy of responding when reinforcement was withheld. Terrace concluded that accuracy of responding during extinction was a function of intermittent reinforcement during errorless training in trial conditions, and suggested that this type of schedule be used to insure desirable results.

The major consideration of most studies with human subjects, apart from evaluating the degree to which techniques used successfully with animals could be extended to human learning situations, has been to demonstrate the superiority of errorless training procedures over the traditional reinforcement-extinction ("trial-and-error") approach in terms of efficiency of learning. Although reinforcement has been accepted as a necessary factor in most studies, the major variable under investigation has been fading versus no fading of one or the other of two stimuli to be discriminated. Even in those studies which went beyond the acquisition phase to investigate retention of a discrimination on some post-training criterion test, retention was seen as a function of the fade-no fade variable.

A training procedure, to be of value, must be both efficient in facilitating learning and effective in maintaining that learning. If errorless discrimination techniques are to be applied more widely to educational settings--a distinct possibility in light of the experimental findings to date--then all variables which might affect the acquisition and maintenance of discriminations taught with these methods should be investigated. As Terrace's (1970) findings indicated, reinforcement schedules may have as much to do with the maintenance of a discrimination as fading does with its acquisition when using errorless techniques in trial conditions. No systematic attempt has been made to investigate the effects of different schedules of reinforcement in errorless discrimination training tasks with humans in trial conditions. This study is an attempt to correct that situation.

CHAPTER II

REVIEW OF THE LITERATURE

This chapter will have a threefold purpose: (1) to present an analysis of errorless discrimination training as conceived and studied with pigeons by Terrace; (2) to describe the experiment upon which the present study was based; and (3) to review the findings of experiments with humans in which various "errorless" procedures were employed.

Errorless Discrimination Training with Pigeons

Terrace (1966) has presented a comprehensive review of his most important experiments using errorless discrimination procedures. Therefore, the present review will be mainly concerned with a brief examination of the theoretical rational for these procedures, a description of the procedures, and a summary of the characteristics of the behavior generated by the procedures.

A discrimination exists when a response occurs more

frequently in the presence of a stimulus correlated with reinforcement (S+) than it does in the presence of a stimulus correlated with nonreinforcement (S-). The objective of discrimination training is to increase the probability of responding to S+ and to reduce the probability of responding to any other stimulus; i.e., S- (Terrace, 1966).

It has been found that following the reinforcement of a response in the presence of one stimulus other stimuli which have never been associated with reinforcement will also evoke that response. Therefore, differential reinforcement of two stimuli is necessary to establish a discrimination. A "conditioning-extinction" theory holds that the process of discrimination is the interaction of "generalization gradients of both excitation and inhibition around stimuli that were associated with reinforcement and extinction respectively" (Terrace, 1966, p. 275). That is, excitation, a tendency to respond, results from the cumulative effects from reinforced responding to S+. Likewise, frustration-produced inhibition, a tendency to not respond, becomes conditioned to S- as a result of nonreinforcement of responding to S-.

Excitation and inhibition tend to generalize to similar stimuli with the amount of generalization seen as a function of decreasing similarity (Hilgard and Bower, 1966). Through a process of differential reinforcement, the effectiveness of S+ is increased to a much greater degree than that of S-. Conversely, nonreinforcement of S- weakens its effectiveness while only slightly reducing the effectiveness of S+. After a period of training in this manner, S+ achieves greater control over responding than does S-. A method of this sort accepts responding to S- as a necessary condition for discrimination learning (Terrace, 1963a).

Terrace's (1966) major concern in developing and investigating errorless discrimination training procedures has been to show that, while differential reinforcement of two stimuli is necessary to establish stimulus control, the occurrence of "errors" (responses to S-) during the acquisition of the discrimination is not. He has attempted to show that a high rate of nonreinforced responding to S- establishes it as an aversive or inhibiting stimulus which produces emotional side effects (Terrace, 1966; 1971).

Terrace's (1963a; 1966) findings also led him to

reject the assumption that discrimination learning can be described in terms of interacting gradients of reinforcement and extinction, and the assumption that generalization and discrimination are inverse processes. If the former assumption were true, a discrimination could only be learned if many S- responses occurred. However, it has been shown that a discrimination can be trained with few or no responses to S-. Terrace questioned the latter assumption on the basis of findings which showed that generalization gradients obtained in extinction were not good predictors of the difficulty of a discrimination when using number of S- responses during acquisition as the comparative criterion.

Terrace's interest in exploring the variables that affected the occurrence of S- responses, and his hypothesis that the number of responses to S- emitted during the acquisition of a discrimination was a joint function of when and how S- was introduced in the training sequence, led him to develop the training techniques known as errorless discrimination training procedures (Terrace, 1963a).

In the initial experiment in which pigeons were taught a red-green color discrimination, Terrace (1963a)

investigated two values within the two variables of time and manner of introduction of S-. The four training conditions which resulted were: (1) Early Progressive: a highly divergent S- was presented early in training and gradually faded across several dimensions until S+ and S- differed in only one distinctive dimension; (2) Early Constant: S+ and S- were presented together early in training, and were identical except in the one distinctive feature; (3) Late Progressive: the divergent S- was faded in late in training after many S+ presentations had been reinforced; (4) Late Constant: after many S+ responses had been reinforced, S- was introduced in its terminal form. Inasmuch as pigeons trained in the Early Progressive condition made few or no errors, the procedures used in this condition were called "errorless."

Not only was error production of subjects trained with errorless procedures quantitatively different from those in the other groups, but error patterns were qualitatively different as well. Subjects trained with errors emitted occasional bursts of S- responses even after learning the discrimination to a perfect criterion. In addition, subjects that learned the discrimination with errors showed "emotional" responses in the presence of S-.

In a second experiment, Terrace (1963b) was able to transfer an errorless discrimination learned on the red and green colors to a vertical-horizontal line discrimination by slowly superimposing the lines over the colors and slowly fading out the colors. In groups where the lines were not faded in or the colors not faded out, subjects made many errors on the line-tilt discrimination. In addition, subjects which had made errors on the line discrimination also made errors when returned to the color discrimination, although the color discrimination had been learned without errors initially. Subjects that learned the line discrimination without errors made no errors when returned to the color discrimination.

Subsequent experiments comparing subjects trained with and without errors strengthened Terrace's conclusion that errors were both unnecessary and undesirable in discrimination learning. In one study (Terrace, 1963c) it was found that two drugs, chlorpromaazine and imipramine, seriously disrupted previously perfect discrimination performances only in those subjects that learned with errors. Subjects taught the discrimination without errors made no responses to S- following administration of the drugs.

In another study (Terrace, 1968), it was found that only subjects trained with errors showed behavioral contrast effect (an increase in the rate of S+ responding due to differential reinforcement of S+ and S-). In addition, only error-prone subjects showed "peak shifts" on generalization gradients taken following discrimination training. Peak shift occurred when the maximum rate of responding was produced at a value displaced from S+ in the direction away from S-.

The results of these experiments were interpreted to show that S- functioned as an aversive stimulus following discrimination learning with errors, but as a neutral stimulus following discrimination learning without errors. One further study (Terrace, 1971) was designed to add further evidence to support this hypothesis. It was found that pigeons who made many errors in learning a discrimination between horizontal and vertical lines also learned to escape from S- by responding to a second key which turned off S- for a short time. Subjects who learned the discrimination without errors, or subjects for whom the second key had no effect on S-, made few responses to the second key. Terrace concluded that these results demonstrated that S- can function as

a secondary negative reinforcer, and that it does so because of the aversive properties it acquires as a result of nonreinforced responding to S-.

To summarize at this point, an attempt has been made to show that errors are neither necessary nor desirable in learning a discrimination. Discrimination performance of subjects trained with errorless discrimination procedures has been shown to be superior to that of subjects trained with other methods in terms of accuracy and efficiency of acquisition. In addition, it has been suggested that a training procedure which necessitates many errors before a discrimination is learned produces emotional behavior which might interfere both with current and future performance. This emotional behavior is thought to be triggered by S- which has become an aversive stimulus as a result of frustration generated by nonreinforced responding to S-.

In spite of the apparent superiority of a discrimination trained without errors, a number of problems have been identified in situations in which a progressive discrimination procedure failed to produce errorless learning. Responding to S- following a previously

errorless performance can be caused by too large a change in the value of S- during fading; by an abrupt reduction in reinforcement density in S+; or by the use of an inappropriate dimension along which the values of S+ and S- are changed (Terrace, 1966).

Terrace (1966, 1970) has also suggested that the reinforcement schedule used in training under certain conditions can also lead to a disruption of a previously errorless performance. It is the analysis of the relationship between reinforcement schedule and errorless performance which is the focus of the present study, and a discussion of experimental findings relevant to this relationship will be presented.

The impetus for the present study derived from a finding by Terrace (1970) that the reinforcement schedule used during certain training conditions had a significant effect on the stability of a discrimination during extinction. On the basis of this finding, it was concluded that errorless procedures might not be desirable under certain conditions unless specific precautions were taken to use intermittent reinforcement during training.

In his initial experiment, Terrace (1963a) used

twenty-four subjects equally divided into four training groups: Early Progressive, Early Constant, Late Progressive, and Late Constant. Each group was further classified into free operant or trial conditions, providing for three subjects in each treatment condition. In the free operant condition, S+ and S- were presented for a specified period of time with the number of responses determined by subjects' response rates. In the trial condition, a single response terminated the stimulus. All responses to S+ were reinforced in the trial conditions. A variable interval schedule of reinforcement was in effect in the free operant condition.

In both free operant and trial conditions, the Early Progressive subjects learned the discrimination with few or no errors. Subjects in the other groups made many errors before the discrimination was acquired. However, when all subjects were put in extinction, those in the Early Progressive group under trial conditions made many responses to S-. Performance was not disrupted for subjects in any of the other groups in either condition. Terrace suggested that this disruption of performance resulted from "frustration" caused by the abrupt shift from continuous reinforcement in training to no reinforcement

in extinction. All other subjects had emitted nonreinforced responses to S+ during training. Only the Early Progressive group in trial conditions had no history of nonreinforced responding before extinction.

Operating on the hypothesis that intermittent reinforcement of S+ responding during training in trial conditions would establish "frustration tolerance" in subjects during the extinction phase, Terrace did a second experiment in which he gradually reduced the probability of reinforcement for responding to S+ from 1.0 to 0.10 for an Early Progressive group of three subjects in trial conditions. Not only did subjects continue errorless responding while the intermittent schedule was being inserted into the program, but the intermittent schedule allowed the errorless performance to be maintained in extinction until responding ceased. Terrace concluded that accuracy of responding during extinction could be insured if responses to S+ were intermittently reinforced during training in trial conditions.

Errorless Discrimination Training Studies with Human Subjects

In appraising the significance of an errorless training approach, Hilgard and Bower (1966) concluded that

> Terrace's procedure brings out strikingly a point of view on learning research that has often been lacking in the past. The viewpoint is one concerned with optimality, and asks questions regarding the best arrangement of training conditions, one that permits the subject to achieve some criterion of good performance. The strategy here would be to devise training sequences to optimize or minimize some such variable as the goodness of the evential performance achieved, the speed of effecting a given change in performance, or producing a desired change with a minimum of frustration, or of difficulty and so forth. Such a research strategy will assuredly yield results of practical relevance to educators, psychotherapists, and others whose concern is with practical behavioral engineering. [p. 522]

A number of researchers have, with varying degrees of success, attempted to adapt errorless discrimination techniques in studies with human subjects, mainly younger normal children and older retarded children. The following is a chronological review of a representative sample of such studies.

Moore and Goldiamond (1964) employed errorless

procedures to minimize S- responding in a task involving form discrimination. Their subjects were six nursery school children ages three to five years. In a delayed matching to sample task, a triangle was presented briefly as a sample. When the triangle was withdrawn, it and two others differing slightly in degree of rotation were presented in different positions. Subjects were required to locate the sample that had been presented. Stimuli were presented on a panel containing four small windows. The sample window was centered toward the top with the other three windows arranged in an arc below it. Subjects indicated their choices by pressing a button below each window.

In the full series, the sample window was illuminated at full brightness. When the sample was withdrawn, the three matches were illuminated at full brightness. In the fading series, the sample was presented and withdrawn as in the full series, but of the three match windows, only the correct one was presented at full intensity. The incorrect stimuli were initially presented at lowered intensities which were gradually increased on successive trials.

A correct choice turned on a small light above the

button, advanced the presentation to the next in the series, and resulted in the subject receiving a small consumable or trinket. An incorrect response resulted in a re-presentation of the step. Two consecutive errors resulted in a regression to a previous step.

Cumulative accuracy graphs of each subject revealed accuracy to be a function of the degree to which incorrect matches were initially presented at differing intensities from the correct matches and the differences gradually faded out by increasing the intensities of the incorrect matches. Moore and Goldiamond concluded that the errorless procedures were more economical than a reinforcement-extinction method in producing learning which was most "perfect" with the least practice. Their functional analysis approach also allowed them to demonstrate the effectiveness of their procedures by the reversibility and reinstatement obtained when the fading procedures were systematically dropped or instated with individual subjects.

Sidman and Stoddard (1967) attempted to evaluate the effectiveness of fading in a program to train retarded children to discriminate circles from ellipses. Subjects were nineteen institutionalized boys ages nine

to fourteen years old. In the Program Group, fading techniques were used to transfer stimulus control from "bright vs. dark" to "form vs. no form" and then to "circle vs. ellipse." The Test Group had to learn the circle-ellipse discrimination with no prior training.

The task apparatus consisted of a square matrix of nine keys onto which stimuli were projected from the rear. When stimuli were displayed, the subject was to press one of the keys. A correct choice caused chimes to sound, moved the series forward to the next presentation, and resulted in the subject receiving an edible. When an incorrect choice was made, the stimuli remained until the subject corrected his error. Also, an error resulted in the series being "backed up" one step following the final correct response.

Seven of the ten subjects in the Program Group learned the circle-ellipse discrimination. Only one of nine subjects in the Test Group learned the discrimination. When the eight non-learners of the Test Group were then trained using the fading procedures, only three were able to eventually learn the circle-ellipse discrimination. These three made considerably more errors than the seven who were given the fading program initially.

Subjects who failed to learn the discrimination adopted response patterns incompatible with the development of appropriate stimulus control.

Sidman and Stoddard concluded that this evidence supported the inference that fading procedures were more effective in teaching discriminations to retarded children than a method which generated errors or depended only on the process of reinforcement and extinction. However, although the training program greatly reduced the errors subjects made, it did not completely eliminate errors. Some of the Program Group subjects were never able to learn the discrimination.

Probably the most significant finding in this study came in the analysis of error patterns which indicated that "...errors were nearly always traceable to reinforcement contingencies inherent in the teaching techniques and conflicting with contingencies deliberately designed to help the children to learn" [p. 15]. For example, procedural features such as correction and backup, the shape of the key matrix, and the response requirements, although not initiating error patterns, determined their forms. Some subjects found that by perseverating on one key or by circling the key matrix

they could maintain relatively high rates of reinforcement. These patterns were more apparent when subjects were faced with a difficult task, but were abandoned in favor of correct choices when they were returned to easier tasks.

Sidman and Stoddard made the point that while subjects in the Program Group made the same types of initial errors as those in the Test Group, these initial errors did not lead them to adopt error patterns as alternatives to correct choices. Sidman and Stoddard concluded: "The appearance of error patterns...must be attributed primarily to the relative ineffectiveness of extinction as a teaching technique" [p. 15].

Using retarded children as subjects, Touchette (1968) sought to determine if a program of graduated stimulus change (fading) could be effective in teaching severely retarded subjects who had already demonstrated no learning under reinforcement-extinction procedures. Subjects were fourteen institutionalized retarded boys ages nine to fifteen years. Subjects were required to discriminate the position of a small black square projected onto a display matrix, and to press the response key closest to it. Every correct response produced a small piece of candy, set off chimes, and moved the program

forward. An incorrect response resulted in the reinstatement of that trial after a short pause.

One group of seven subjects was given "trial-and-error" training, and only one learned the discrimination. The six non-learners were then presented with a program of graduated stimulus change, and five learned the discrimination. Six subjects were presented with the graduated stimulus change alone, with all six learning the criterion discrimination with no errors. When both groups were tested for retention of the criterion performance thirty-five days after completion of training, two subjects who had reached near-perfect discrimination performance with fading after having failed to acquire the discrimination with trial-and-error procedures showed signs of retention. Five of the six who learned the discrimination initially with fading showed excellent retention.

Touchette concluded that retarded children who were unable to learn a discrimination by trial-and-error could be taught by a program of graduated stimulus change. He further suggested that a history of trial-and-error training might interfere with acquisition and retention of a discrimination, even when fading was used later.

In addition to evaluating the effects of a fading versus a constant method of introducing S-, Cohen et al. (1968) also were interested in the effects of two response contingencies--delay versus no delay--on the occurrence of S- response. Subjects were twenty-seven kindergarten children. Stimuli were a horizontal and a vertical line projected onto a screen. The response consisted of pushing on the screen, and each S+ response was followed by a piece of candy.

Subjects were divided into three groups: (1) fading-no delay, in which S- was gradually increased in intensity and duration until it matched that of S+. A response to S- immediately terminated it, and it was then re-presented; (2) constant-no delay, in which S+ and S- were kept at the same intensity and duration throughout training. A response to S- had the same result as that in the fade-no delay condition; (3) constant-delay, which was identical to the constant-no delay condition in terms of presentation of S+ and S-. However, with the delay contingency, each response to S- reset a timer, so that five seconds during which no S- responses occurred had to elapse before S- was terminated. Subjects were trained until they went through one session of twenty

presentations of each stimulus with no S- responses.

The three training groups were later subdivided for posttraining sessions. Three subjects from each group were given a retention test two weeks after training, reversal training immediately after training, and reversal training two weeks after training. "Fading" subjects made fewer errors than "constant" subjects, and constant-delay subjects made fewer errors than constant-no delay subjects during acquisition of the discrimination. Although S- responding was extinguished within constant-delay group sessions, there was spontaneous recovery between sessions. In the constant-no delay group, two subjects did not reach criterion in sixteen sessions. There was also a significant difference between fading and constant groups in the number of intertrial responses with the latter group having the greater number of irrelevant responses.

Results of the retention test showed that S-responding during acquisition was a good predictor of S-responding in a retention test. When S- responses did not occur in original learning, and, hence, were not extinguished, they were not likely to occur in post-criterion performances. In immediate reversal training,

fading subjects responded to the new S+ more readily, leading Cohen et al. to conclude that the new S+ (the former S-) had little inhibiting effect for this group.

From the finding that subjects in the delay group made fewer errors than the no-delay group, Cohen et al. suggested that an immediate offset of S- with a response to it acts as reinforcement, whereas a delay in the offset of a period of nonreinforcement acted as punishment.

Le Blanc (1968) attempted to compare the effects of errorless discrimination procedures with trial-and-error procedures in matching to sample tasks. Each of eight preschool children performed eight tasks each involving a fifty-two slide presentation in eight different sessions. Within each session, errorless procedures and trial-and-error tasks were alternated. The task stimuli were pictures of geometric figures that were rotated at different angles from the sample orientation of zero degrees.

Stimuli were projected onto a sample window and four match windows on a display panel. With the errorless discrimination tasks the sample figure and the correct match were always at full illumination. Initially,

the three incorrect choices were dark, then gradually faded to full intensity. Also, the form was initially quite different, and was faded to resemble the sample. For the trial-and-error tasks, all figures were at full illumination and similarity. A response consisted of pressing the window which contained the correct match. Correct choices were followed by marbles which could be later exchanged for toys.

Children in neither group were able to learn the discrimination. Le Blanc concluded on the basis of subsequent experimentation with adults that the tasks were too similar to permit the desired comparison. She also suggested that in using single subjects and an alternating presentation sequence, discriminations learned in one task tended to generalize to those in other tasks.

Golin and Savoy (1968) were interested in the effects of using fading procedures during discrimination reversal training upon subsequent solution of a conditional discrimination problem. Fifty-two nursery and elementary school children ages three to nine were trained on two-choice discrimination tasks with either fading procedures or a traditional procedure. Stimuli were triangles or circles with one or several stripes

on a dark background. Stimuli were projected onto a two-window display panel, and subjects responded by pressing one of the windows. A correct response caused a red light to come on over the pattern. In the fading condition, the S+ appeared at full brightness with the other window dark initially. The brightness of the geometric shapes and the lines were faded in during subsequent presentations. In the traditional condition, both S+ and S- were at full brightness from the beginning of training.

Subjects received twenty fading and twenty reversal trials, and twelve conditional trials. In reversal training, the original values of S+ and S- were reversed. In the conditional discrimination test, the cue-background combinations were presented in random order with the subject required to respond to the stimuli which were reinforced during original and reversal training.

Results showed that more subjects trained by the fading procedures performed without errors during original and reversal discrimination, while more subjects trained by the traditional procedure made fewer errors during the conditional discrimination tasks. There was no indication that absence of errors during original discrimination was associated with a reduction of errors

during reversal. Golin and Savoy concluded that the gradual introduction of S- did not provide subjects with sufficient comparative experience to permit efficient transfer to the conditional task. They suggested that access to S+ and S- throughout training might be facilitating.

Crist (1969) investigated the effectiveness of errorless discrimination training in teaching retarded children to pair a given letter symbol with a specific sound, and the extent to which the letter-sound discrimination would generalize to the skill areas of emitting the desired sound when shown the letter and of constructing the letter when the appropriate sound was presented. Subjects were four mentally retarded boys in special aid classes.

Letters of the alphabet were randomly divided into two stimuli presentation methods. A teaching machine was used to present three letters, one of which matched the sound given by the experimenter. In the errorless procedure, the two incorrect stimuli were initially out of shape and slowly faded to their final forms. In the trial-and-error method, the three letters were identical except for their distinctive shapes. Each subject was

alternately exposed to each of the two methods. A session ran for fifteen minutes with seventy-four items presented each session.

Pre- and post-test data revealed that the errorless training procedure was as effective as the trial-and-error method in producing gains. However, analysis of daily performance data showed that the errorless approach resulted in a higher percentage of correct responses made in less time than did the other method. The letter-sound associations which were mastered did not often generalize to related verbal skills for either method. Crist provided two explanations as to the failure of the errorless method to produce superior gains. With the fading procedures, the subjects could choose the correct letter without listening to the sound cue. This may have hindered learning by reinforcing poor attention. In addition, alternating the two presentation methods with the same subjects may have caused the effects to generalize from one method to another.

The effectiveness of stimulus shaping as opposed to traditional trial-and-error training methods with retardates was investigated by Auger (1969). Subjects were compared in the number of trials required to exhibit

two specific discriminatory responses: a key pressing response to S+ and a non-key pressing response to S-. The stimulus shaping group exhibited the stimulus-response relationship in fewer trials and contained a higher number of subjects who exhibited the relationship in the allotted number of trials.

There was a significant difference in the types of errors for the groups with the stimulus shaping group exhibiting more key pressing errors while the trial-and-error group displayed a greater avoidance toward key pressing. In an auxiliary experiment, Auger failed to find differences on a generalization gradient of subjects trained with the two methods. This led him to suggest that displacement observed in other studies following trial-and-error training may not be a generalized principle, but may be specific to stimuli and procedures. Auger also found no significant differences between responses patterns for males and females.

Bricker _et al_. (1969) compared fading and position-extinction procedures in isolation and in combination with trial-and-error procedures in a two-choice discrimination task with sixteen institutionalized retardates ages seven to sixteen. A position-extinction

procedure is one in which the placement of the correct stimulus is varied so that the possibility that a particular position pattern can both be developed and extinguished. Bricker et al. were interested in seeing if these two procedures, which had been used successfully to facilitate the learning of individual discrimination problems, would also operate to facilitate the broader capability of learning set.

The training program consisted of ninety-six color-form problems divided equally into eight blocks each containing twelve problems. Terminal criterion for completion of each problem was either five consecutive correct responses with both color-form stimuli at full brightness, or ninety-nine trials without achieving criterion. A correct response was followed by a chime, and every fifth consecutive correct response was followed by an edible. All incorrect responses were followed by a loud buzzer. Following the completion of each block of twelve problems, four test problems were administered. In each test problem, S+ and S- were kept at maximum illumination and alternated randomly from side to side. Each problem consisted of nine trials whether criterion was reached or not.

Subjects were assigned to one of four conditions. In the fading condition, S- was dark initially. Each correct response produced one increment of illumination for S- while each error produced one decrement. The terminal criterion could be reached only after S+ and S- were of equal brightness. An errorless performance on a problem required a minimum of fourteen trials. The other three conditions were control (reinforcement-extinction), fading-position extinction, and no fading-position extinction.

Bricker et al. found that learning occurred during the course of the experiment for all but the control group. Fading procedures produced the best performance, although the difference was not statistically significant. However, there was little evidence of learning on test problems for any of the groups. Bricker et al. offered two suggestions for the lack of transfer of appropriate behavior from the training with fading to the testing problems. First, inappropriate programming--i.e., too rapid fading of cues--may have demanded subjects to make too large a step from training to test problems, thus producing a deterioration of learning-set behavior. Second, the fading techniques could have been ineffective

or inappropriate for developing learning-set behavior. Bricker _et al_. suggested that "...fading in of the negative cue may not necessarily lead to appropriate learning-set behavior, no matter how slowly the cue is faded" [p. 247].

Schaeffer (1970) also investigated the effects of fading versus a reinforcement-extinction procedure in learning-set formation. Forty-five institutionalized retarded children matched on the basis of MA, CA, and IQ were placed in one of three training groups: (1) Group I--fading applied throughout training; (2) Group II--fading applied only to the first problem; (3) Group III--full series throughout training.

Ten geometric designs were arranged into pairs to form five equally difficult two-form discrimination problems. Subjects had the task of placing the correct form (S+) on one circle of a six-choice paper test sheet, and placing the incorrect form (S-) on the remaining five circles. In the fading condition, the S+ circle was much brighter than the S- ones. On successive trials the brightness difference was gradually reduced until the criterion discrimination level was reached.

Schaeffer found that the fading groups had

statistically significant superior performance not only in terms of efficiency with which the learning set was acquired, but also in terms of the speed of acquisition. Contrary to prediction, however, he found no significant differences between the performance of Groups I and II. While some subjects in all groups displayed inattentiveness and multiple error patterns, these were more numerous in Group III. Schaeffer concluded that this study demonstrated that errors are not necessary for the learning process, and that once made, they adversely affect subsequent performance.

Karraker and Doke (1970) attempted to analyze conditions under which errorless discrimination would occur using kindergarten children as subjects. The major objectives were to: (1) compare error production of subjects with four different methods of S- presentation; (2) compare behavior on simultaneous and successive discrimination tasks following successive discrimination training; and (3) evaluate the effectiveness on discrimination learning of fading the lower-case alphabet letters "b" and "d" over dimensions of color, size, and duration of presentation.

Sixty-two kindergarten pupils were equally divided

into four groups according to the time and method of S- presentation: (1) Early Progressive--fading in of S- early in training; (2) Early Constant--introduction of S- early in training, but with no fading; (3) Late Progressive--fading in of S- late in training; (4) Late Constant--introduction of S- late in training, but with no fading. In the progressive, or fading, condition, S+ was initially larger than S-, and was gradually reduced until they were the same size. Also, S+ was either red or green (depending on whether "b" or "d" was S+) and the color was slowly eliminated. Finally, S- duration was at first about one second, and was progressively increased to five seconds. Each correct response was followed by praise from the experimenter, and resulted in the presentation of the next stimulus.

Subjects received 180 trials in the initial successive discrimination training, fourteen trials in simultaneous discrimination training, and sixty-two trials in the later successive discrimination training. This latter training could be considered a post-training test since S+ and S- were identical in all respects except distinctive form.

The most significant findings of Karraker and Doke

were: (1) the progressive method of introducing S- was more effective than the constant method in minimizing errors during training; (2) the early presentation of S- was more effective than the late presentation in minimizing errors during training; (3) during simultaneous discrimination training following training on a successive discrimination, error proportions for the early and late constant groups were more substantially reduced than for the early and late progressive groups; and (4) during later performance on successive discrimination Early Constant and Early Progressive subjects made fewer errors than the Late Constant and Late Progressive group subjects. In addition, within the Early Progressive group, errorless discrimination was not replicated with all subjects, suggesting that the dimensions over which stimuli were faded were not appropriate for all subjects. However, Karraker and Doke concluded that this study demonstrated that procedures found to produce errorless discrimination learning in the laboratory could be applied to teaching a discrimination of socially significant stimuli; i.e., alphabet letters.

Egeland and Winer (1972) also conducted an experiment using alphabet letters as stimuli in discrimination

training tasks. Two groups of thirty-two kindergarten pupils were taught to discriminate four different upper-case letter combinations by one of two training methods: an errorless procedure in which no corrective feedback was given and a reinforcement-extinction method in which subjects were told after each trial if the response was correct or incorrect.

Treatment consisted of three warm-up trials with geometric designs, ten training trials, and four post-test trials for each of two letter combinations. Stimuli were presented in a match to sample format, with the sample at the top of a card and six choices--three correct and three incorrect--below. In the errorless discrimination condition, the relevant cue of the letter to be discriminated was highlighted in bright red. On subsequent trials, the color was faded until on the tenth trial the correct letter was identical to the incorrect ones except in respect to their respective shapes. In the reinforcement-extinction condition, all letters were identical except for shapes. Each group was taught by a different experimenter.

A separate analysis was done on number of errors during training trials and on the post-test. The

errorless procedure was significantly better than the reinforcement-extinction method in minimizing errors in both training and the post-test.

Egeland and Winer concluded that these results indicated that the argument that a child must make a number of errors in order to eliminate responding to the irrelevant cues of the discrimination stimuli is invalid. They further concluded that the feedback was not much help to subjects in the reinforcement-extinction group.

In summary, both normal and retarded children have been used in a variety of studies emphasizing errorless discrimination training procedures. The major concern in these studies was to demonstrate the superiority of errorless procedures over other methods. It has been found that a training procedure which uses some system of gradual stimulus change (fading) is generally more effective in facilitating the acquisition of a discrimination than some method which is based on a trial-and-error approach. It has also been shown that errorless procedures are effective in helping some subjects acquire a discrimination they were unable to learn with a trial-and-error method. Findings have

also suggested that making errors during training may interfere with later learning, transfer, and retention.

On the other hand, errorless training has not been totally successful for all subjects nor in all situations. Some subjects have been unable to learn a discrimination even with fading, and, in some cases, subjects who were trained with fading procedures did more poorly on later post-criterion tests than subjects who had learned with errors.

The critical variable in these studies, and the one most closely associated with the concept of errorless training, was fading. Either S- was faded in or a distinctive cue on S+ was faded out. While some form of reinforcement has been seen as a necessary component of errorless procedures in all but one study, neither the type of reinforcement nor the schedule of reinforcement has been studied as an independent variable.

CHAPTER III

MATERIALS, PROCEDURES, AND DESIGN

This chapter will provide a description of the stimulus materials, apparatus, and design used in this study. Procedures for selecting subjects and conducting the experiment will be explained. The method of data analysis and presentation will also be discussed.

Stimulus Materials

Letters of the alphabet were chosen as stimuli for this study because previous studies indicated that they could be taught to kindergarten subjects using errorless discrimination techniques (Karraker and Doke, 1970; Egeland and Winer, 1972). Learning letters of the alphabet is also a task particularly relevant in kindergarten (Karraker and Doke, 1970; Guralnick, 1972).

Two pairs of letters were used: lower case "b" and "d" and upper case "P" and "R." The letters "b" and "P" were arbitrarily designated S+ and the letters "d" and "R" were designated S-. Black letters were printed on

light blue cards approximately 3 5/8 x 8 1/2 inches. Two sets of cards for each letter pair were used: a fading set and a regular, or full series, set. Samples of letters used in the experiment are included in Appendix A.

The fading set was comprised of thirty S+ and thirty S- cards. S- was different from S+ in size and shade of blackness. S- was initially larger and grayer than S+ and was gradually reduced in size and increased in blackness on succeeding cards. On the last three cards, S- was identical to S+ except in shape. In the full series set, S+ and S- differed only in terms of their distinctive shapes. S+ was the same size and shade in both sets. The shade of S- was controlled by a screening process in offset printing. Size and shade of S- relative to S+ are summarized in Table 1.

Once the study got underway it became necessary to alter the "b" and "d" stimulus cards in the fading set. During the first training session, none of the subjects learned the discrimination. When the same was true for the first two subjects in the second session, the other two subjects were not run. It was apparent that the dimensions over which S- was being faded were not sufficient to bring the subjects' responding under the

Table 1

Sizes and Shades of S- Stimuli Relative to S+ Stimuli in Fading Series

Card Number (In Order of Presentation)	Size (Relative to S+*)	Shade (Relative to S+)
1-3	5.0X	10%
4-6	4.5X	20%
7-9	4.0X	30%
10-12	3.5X	40%
13-15	3.0X	50%
16-18	2.5X	60%
19-21	2.0X	70%
22-24	1.5X	80%
25-27	1.25X	90%
28-30	1.0X	100%

*Size of S+: 4 x 8 mm

control of the distinctive feature distinguishing the two letters. Terrace (1966) reported that "...the use of an inappropriate dimension along which the values of S+ and S- are changed will disrupt a previously errorless performance" [p. 315]. There is also evidence to indicate that some letters of the alphabet are more difficult than others to discriminate (Egeland and Winer, 1972; Guralnick, 1972). On the basis of techniques described in several sources (Egeland and Winer, 1972, Guralnick, 1972), a color cue was added to highlight the distinctive feature of each letter, and was gradually faded out or "vanished."

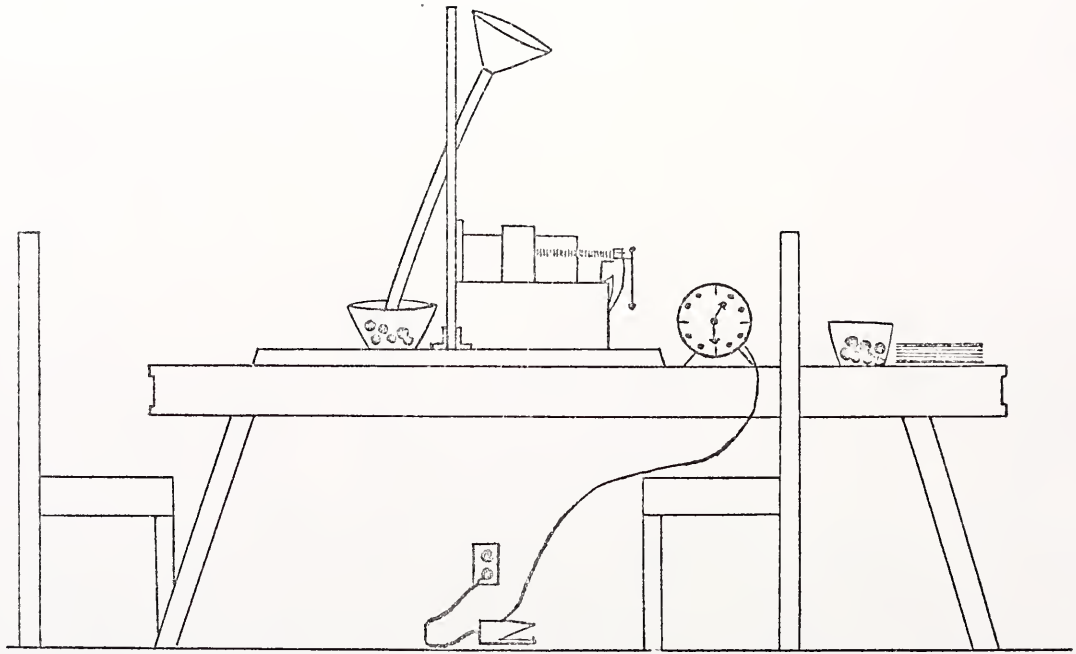
Using a blue Magic Marker, a border was drawn around the outside edge of the "hump" on the letter "d." The color was put on all thirty "d's" in the fading set, but the size of the border was gradually reduced until on the thirtieth card it was a barely discernable dot. An orange border was placed around the outside edge of the "hump" of "b," and it was gradually faded out over the first fifteen cards. This procedure was successful for all subjects as they learned the discrimination in one session with the color.

Apparatus

The apparatus employed in this study was a card presenter constructed of plywood (Figures 1 and 2). A 15 x 21 inch panel was afixed to a base. A slot approximately 3½ x 7½ inches was cut in the center of the panel two inches from the base. A small platform served as a card holder on E's side of the panel, permitting a prearranged stack of stimulus cards to be presented one at a time through the slot. As cards were shown and removed, the remaining cards were moved forward toward the viewing slot by turning a clamp screw connected to a backing board behind the stack of cards.

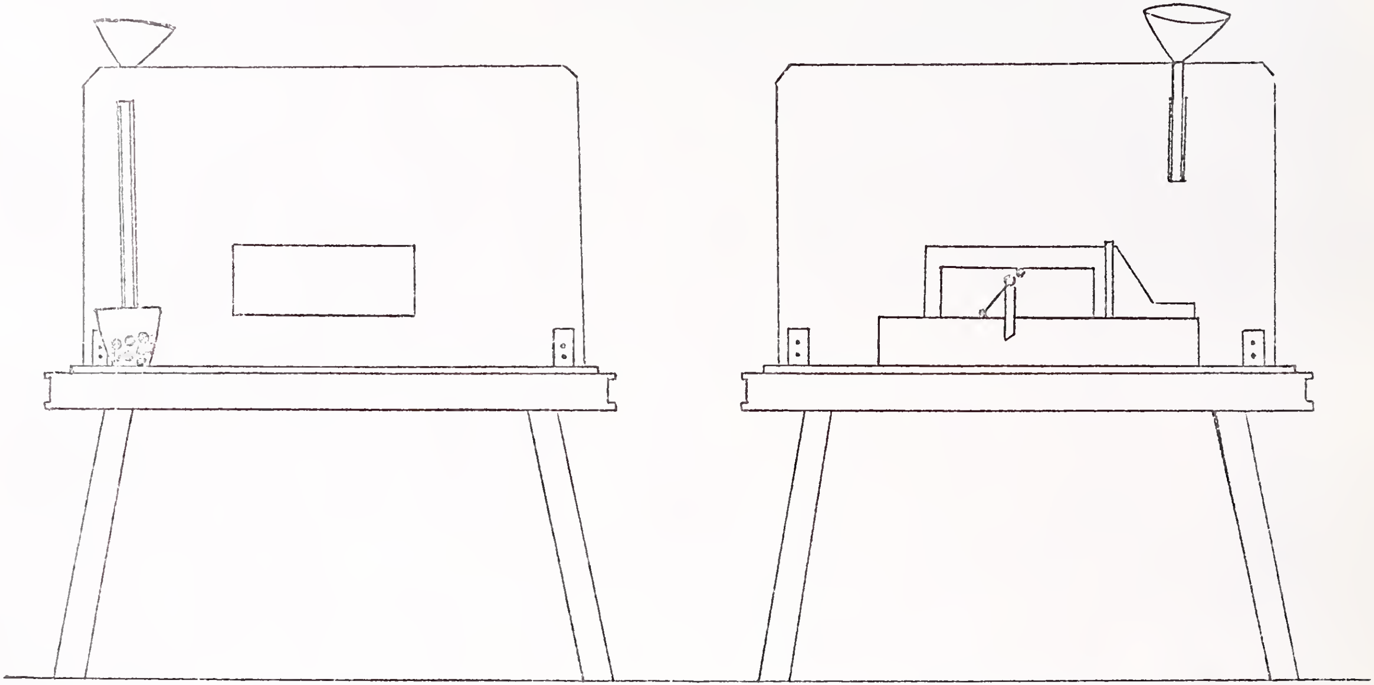
A transparent plastic container was placed below and to the left of the viewing slot on the subject's side of the panel. The container was connected to E's side by a 3/4 inch plastic tube. A metal funnel was attached to the upper end of the tube through which marbles were deposited into the container when subjects made correct responses. Marbles could be exchanged for pennies on a ratio of five to one at the end of each subsession.

An electric clock on E's side was connected to an electric sewing machine foot pedal. By manipulating



Side View

Figure 1. Experimental Apparatus.



Front View

Back View

Figure 2. Experimental Apparatus

the pedal, E could run the clock during the presentation of cards and stop it while marking responses, delivering marbles, adjusting cards, etc. A container of marbles was kept on E's side of the panel.

Subjects

Kindergarten teachers in a local elementary school were asked to identify boys who were unable to name letters of the alphabet. These children were then tested individually by showing each a series of cards on which upper and lower case alphabet letters were typed with a primary typewriter. Three upper case and three lower case letters were randomly chosen in addition to the four letters used in this study. Upper case letters were "J," "O," and "X." Lower case letters were "f," "t," and "y." Each letter was typed on three separate cards, making a total of thirty cards. The cards were placed in a stack and shuffled before each child was tested. Any child who correctly named any of the letters used in this experiment was excluded. Four boys were chosen at random from those who were unable to name any of the letters. These four were then randomly assigned to one of two letter pair-reinforcement schedule

combinations. Ages of subjects in months were: Subject 1, 64; Subject 2, 65; Subject 3, 70.5; and Subject 4, 69.5. School records indicated that all subjects had normal hearing. Subjects came from families designated by teachers as being of low socioeconomic status. All four subjects were Black.

Experimental Procedures

Design

A within-subjects design was employed in this study, providing for each subject to be exposed to two treatments during each training session. This was accomplished by giving each subject discrimination training on two letter pairs, each of which was correlated with a different reinforcement schedule.

The experiment was divided into three phases: acquisition, maintenance, and extinction. During the acquisition phase, both letter pairs were reinforced on a continuous reinforcement schedule. Treatment began during the maintenance phase. While one letter pair continued to be reinforced continuously, an intermittent schedule was "faded in" for the other letter pair. This schedule was derived from that used by Terrace (1970) in

which the probability of reinforcement was initially 1.0 and was gradually reduced to 0.75, 0.50, and 0.25 until the final level of 0.10 was reached. During the extinction phase, reinforcement was withheld.

For two subjects the letter "b" was S+ and the letter "d" was S- in the continuous reinforcement condition. The letter "P" was S+ and the letter "R" was S- for these two subjects in the intermittent reinforcement schedule condition. These letter pair-reinforcement schedule combinations were reversed for the other two subjects. The experimental design and the letter pair-reinforcement schedule combinations are presented in Table 2.

General Procedures

This study was conducted during the last six weeks of the school year. Sessions were held for a subject each day he was at school during this period. Sessions were conducted in a basement room of an elementary school. E brought each subject to the room and returned him to his classroom.

Each session was comprised of two subsessions. During one subsession, the subject was given training

Table 2

Experimental Design and Letter Pair-
Reinforcement Schedule Combinations

	Phase I Acquisition		Phase II Maintenance			Phase III Extinction
Subjects	CRF	CRF	CRF	INT	NONE	NONE
1	S+: b S-: d	S+: P S-: R	S+: b S-: d	S+: P S-: R	S+: b S-: d	S+: P S-: R
2	S+: b S-: d	S+: P S-: R	S+: b S-: d	S+: P S-: R	S+: b S-: d	S+: P S-: R
3	S+: P S-: R	S+: b S-: d	S+: P S-: R	S+: b S-: d	S+: P S-: R	S+: b S-: d
4	S+: P S-: R	S+: b S-: d	S+: P S-: R	S+: b S-: d	S+: P S-: R	S+: b S-: d

CRF: Continuous Reinforcement

INT: Intermittent Reinforcement

NONE: No Reinforcement

on the letter pair which had S+ correlated with continuous reinforcement, and during the other subsession he was given training on the letter pair which had S+ correlated with intermittent reinforcement. Daily order of letter pairs was randomly arranged with the restriction that no letter pair would be presented first on more than two consecutive sessions (See Appendix B).

The length of each subsession varied considerably depending on the amount of irrelevant intertrial behavior. Generally, a subsession lasted about ten minutes. However, only net time was used for computing frequency of responding. That is, stimuli were available to the subject for responding for a total of five minutes in the acquisition phase and for three minutes each in the maintenance and extinction phases.

The number of stimulus cards which could be presented in a subsession was controlled by a subject's frequency of responding to S+. For example, with the net time set at three minutes, thirty S+ and thirty S- cards could be presented if the subject responded to S+ within one second of onset, and if he made no responses to S-. More responses could be made during the fading session of acquisition since the duration of S- varied

as part of the training procedures.

For the purpose of this study, a trial was defined as the period during which a stimulus card was presented to the subject. An equal number of S+ and S- cards were prearranged in random order with the restriction that no stimulus was presented more than twice consecutively. A blank card separated each stimulus card from the one following, thus allowing E to control the rate of presentation of cards.

The duration of an S+ trial was controlled mainly by the subject's latency of responding. A correct response occurred when the subject named S+ when it was presented. Such a response within five seconds of the onset of S+ immediately terminated that trial. If no response occurred within five seconds of the onset of S+, it was removed and re-presented as the next trial. This was done by placing a blank card over the S+ card, and placing them at the front of the stack.

Duration of an S- trial was less variable than that of the S+ trial. An incorrect response occurred if the subject made any naming response when S- was presented. In the fading session, duration of S- varied from one to five seconds as this was one of the fading dimensions.

In all other sessions, duration of S- was five seconds if no responses were made to it.

Three correction procedures were used when an incorrect response occurred. First, the stimulus was re-presented as the next trial. Second, the stimulus was not removed until five seconds elapsed during which no responding occurred. This procedure was based on a finding that the immediate removal of S- following a response to it could adventitiously reinforce S- responding (Cohen et al., 1968). Third, a marble was immediately removed from the container on the subject's side of the panel. Favell et al. (1967) found a punishment procedure ineffective in controlling incorrect responding in attempting to train children to fade out a stimulus cue. The ineffectiveness was attributed to the delay in waiting until the end of the session to subtract the cost of using the stimulus cue.

A short break separated subsessions. During this time the subject was allowed to exchange his marbles for pennies. Also during the break E reset the clock, returned the subject's marbles to E's container, and placed the second stack of cards in the card holder. Presentation of stimuli, recording of responses, timing

of trials, and delivery of marbles were done manually by E. Responses were marked on a Response Record Sheet (Appendix C) which contained each subject's name, letter pair-reinforcement schedule combination and order of presentation, a list of S+'s and S-'s correlated with the stack of cards for each session, and total correct and incorrect responses and frequencies.

Acquisition Phase

Subjects were run individually. E went to each subject's classroom the first day and accompanied the subject to the basement room. Following a short "get acquainted" period, the subject was seated at the end of a low table on which the card presenter was placed. E sat at the side of the table to the subject's right facing the subject. The following instructions were read by E to each subject:

> We are going to play a game. Sometimes you will be able to win marbles which you can later exchange for pennies. Five marbles are worth one penny. Look at the slot in front of you. I am going to show you some cards through the slot. When I say "What is this?" you tell me what it is. If you can name what is on the card, marbles will sometimes be dropped into this container. Leave them there until we finish, and we will trade them. When

> I ask "What is this?" you answer real loud so I can hear. Do you have any questions?

When E was satisfied that the subject understood the instructions, the session was begun. This part of the training consisted of showing the subject four cards, one at a time, with pictures of objects expected to be familiar to most kindergarten children. The pictures were of a ball, a fish, a chair, and a shoe. As each picture was presented, the experimenter asked, "What is this?" When the subject correctly named the picture, E dropped a marble through the tube into the container. This preliminary training was designed to familiarize the subject with the procedures, to insure that he was attending to the cards, and to establish the marbles as reinforcers for correct responding. Immediately after this initial training, the first subsession of the experiment began.

The first part of the first subsession consisted of fifteen nondifferentially reinforced trials with S+. The purpose of this training was to insure that the subject could name the letter and to further train the subject to respond to the cards. This part of the subsession was not timed. Immediately following the last

picture presentation in preliminary training, E read the following instructions to the subject:

> I am now going to show you a letter of the alphabet and tell you its name. You look at the letter and repeat its name after me.

The letter designated S+ was then presented. The experimenter said, "This is the letter ______. Now you say it." If the subject responded correctly, a marble was delivered and the card removed. If the subject responded in any other way, the experimenter repeated the instructions until the subject responded correctly and received a marble.

When E was satisfied that the subject was accurately responding, he read the following instructions:

> From now on, when this letter is presented I want you to tell me its name. If anything else is on the card or if it is blank, do not say anything.

Following the fifteenth S+ presentation, fading procedures were instituted.

For the fading session, thirty S+ and thirty S- cards were randomly arranged with the exception that no stimulus was presented more than twice consecutively. In addition to fading along the dimensions of size and shade (and color for the altered "b-d" cards), the duration of

presentation of the S- cards was gradually increased from an initial one second to a final five seconds. The first six S- cards were presented for only one second, the next six for two seconds, etc. S+ was not changed, and duration of S+ was five seconds or less depending on the subject's response. If all sixty cards were presented within the five minute limit, additional S+ and S- cards were presented until accumulated time reached five minutes. All correct responses were followed by delivery of a marble. All incorrect responses resulted in the institution of the correction procedures. Two additional five minute sessions for each letter pair with continuous reinforcement for S+ responding were held on two subsequent days.

Maintenance Phase

The intermittent reinforcement schedule was initiated during the maintenance phase. Time for each subsession was reduced to three minutes. The intermittent reinforcement schedule was similar to that used by Terrace (1970). However, he instituted his schedule by the calendar; i.e., he set a specific number of sessions for applying different levels of the schedule. It was

felt that in this study it would be best to move from one level to another on the basis of the subject's responding. Different levels of intermittent reinforcement would be applied if the frequency and accuracy of responding were stable.

In the continuous reinforcement schedule, the probability of reinforcement for a correct response was 1.0. In the intermittent condition, the probability of reinforcement for a correct response was initially 1.0, and was reduced gradually from this level to 0.75, 0.50, and 0.25 until the final level of 0.10 was reached. This final level was continued until responding became relatively stable.

Extinction Phase

During the extinction phase, reinforcement was withheld. The container of marbles was removed from E's side of the table, and E ignored subjects' questions as to what had happened to the marbles or why they were no longer receiving marbles and pennies. This phase, and the experiment, ended on the last day of school.

Analysis of Results

Results of this study will be presented graphically on the Standard Behavior Chart (Pennypacker *et al.*, 1972) and numerically in tabular form. The Standard Behavior Chart (SBC) is a six-cycle semi-logarithmic chart which uses frequency of responding as the basic datum. Frequency is calculated by dividing the amount of time spent recording a behavioral movement into the number of movements counted during that time. It is plotted on the SBC by locating the day number on the abscissa, the frequency on the ordinate, and then placing a dot or some other mark where these lines intersect on the chart.

A number of measures can be derived from frequency. One of the most relevant in studying accuracy of responding is "celeration," which is the basic unit of behavior change. Specifically, celeration is a change in frequency per unit of time, and has as its unit movements/minutes/week. Celeration is represented on the SBC by a line of best fit to the data in question, and indicates the trend of the behavior change. A line moving toward the top of the chart represents an increase in frequency, while one moving toward the bottom of the chart represents a decrease.

Celeration can also be represented numerically as the amount by which the frequency on a given day must be multiplied or divided to get the frequency one week later. A celeration value with a multiply sign (x) indicates that the frequency is increasing. One which has a divide sign (÷) indicates that the frequency is decreasing. A celeration of x1.0 represents a straight line.

By plotting frequencies for both correct responses and errors, one can readily determine the accuracy on a given day by noting the distances which separate them, and by noting their relationships to the record floor. The record floor is a convention used to allow a zero frequency to be plotted. It is the lowest behavior frequency which can be plotted during a specified recording period, and is derived by the formula: 1/number of minutes spent recording the behavior. The record floor is indicated on the SBC by a straight line drawn from the Tuesday to the Thursday line at the appropriate frequency. A zero frequency is represented by placing a dot or some other mark just below the record floor.

A sensitive measure of accuracy change over time is the celeration ratio, or improvement index. The improvement index is the ratio of two celerations, and, in this

study, represents the ratio of correct celeration to error celeration. The improvement index can be represented numerically, and the sign determines the degree of improvement. An improvement index with a multiply sign (x) indicates that accuracy is improving, while an improvement index with a divide sign (÷) indicates that accuracy is deteriorating. In the case of an improvement index of x1.0, the two celerations are parallel, thus indicating that accuracy is stable. The average change in accuracy for a group can be represented by the geometric mean which can also be represented graphically and numerically.

Celerations and improvement indices for correct and error frequencies for both reinforcement schedules will be presented in chart form for each individual and for all subjects in summary form. A chart representing geometric means will also be presented. In addition, all data will be presented numerically in tabular form.

CHAPTER IV

RESULTS

The purpose of this study was to investigate the effects of continuous and intermittent reinforcement on the maintenance during extinction of a discrimination learned with errorless discrimination procedures. Errorless procedures were used to teach each of four subjects to respond when one alphabet letter was presented and to refrain from responding when another was presented. Each subject learned two separate letter-pair combinations during the acquisition phase with correct responding for both letter-pair combinations reinforced on a continuous schedule. The acquisition phase consisted of one fading session and two full series sessions when S+ and S- were identical except in their distinctive shapes.

During a maintenance phase, one letter-pair was gradually shifted to intermittent reinforcement while the other letter-pair was maintained on a continuous reinforcement schedule. In the intermittent reinforcement

condition, each subject received one maintenance session with the probability of reinforcement at 0.75, two sessions at 0.50, and one session at 0.25. Subjects 2, 3, and 4 received six sessions with the probability of reinforcement at 0.10, and Subject 1 received nine sessions at 0.10.

Extinction was instituted for each subject following the last 0.10 session. Subject 1 received eight extinction sessions; Subject 2 received nine; Subject 3 received eleven; and Subject 4 received ten.

In addition to the alteration of "b-d" stimulus cards, two other changes in procedures were made during the course of the experiment. One of the correction procedures was the removal of a marble from the subject's container for each error. It was discovered during the early sessions of the maintenance phase that Subject 4 was "playing a game" with the experimenter with this correction procedure. Subject 4 would make an error and lose a marble to see if he could win it back. It was decided to increase to three the number of marbles to be taken for an error. In an effort to keep procedures as consistent as possible for all subjects, this procedure was used for all subjects for the

remainder of the maintenance phase.

There was also a good bit of irrelevant intertrial behavior among subjects, necessitating long sessions and increasing the changes of adventitious reinforcement of this type of behavior. It was decided to attempt to gain control over attending behavior by giving subjects M&M's for sitting and looking at stimulus cards. Each subject was usually given about four M&M's each subsession, one at the beginning and one after a minute had elapsed on the clock used to time stimulus card exposure. In an effort to prevent the candy from becoming paired with correct responding, M&M's were never delivered after a correct response, but only after an S- had been presented.

Both the punishment procedure and the reinforcement of attending behavior were begun with Session 8 for Subjects 1 and 4, and with Session 9 for Subjects 2 and 3. The punishment procedure ended when extinction began inasmuch as subjects could earn no marbles during that phase. However, candy for attending behavior was stopped at different times for the four subjects as a means of attempting to assess its effects on responding behavior. The last session for giving candy to each subject was:

Subject 1, Session 17; Subject 2, Session 19; Subject 3, Session 18; and Subject 4, Session 16.

Results of Grouped Data

Results of grouped data will be presented in tabular and graphic form. Geometric means for celerations for correct frequencies, celerations for error frequencies, and celerations for improvement indices for acquisition, maintenance, and extinction phases for continuous and intermittent reinforcement schedules are presented in Table 3. These means were derived from individual subjects' celerations (Table 4). Graphic representation of means for celerations correct and errors along with the best and worst celerations for each phase are shown for the continuous reinforcement schedule in Figure 3 and for the intermittent schedule in Figure 4. Graphic summaries of celerations correct and celerations errors under continuous reinforcement and intermittent reinforcement schedules are shown in Figures 5 and 6, respectively.

One question of interest was whether or not subjects learned the discriminations. Although an analysis of the acquisition of the discriminations was not the

Table 3

Geometric Means by Phases for Celerations Correct, Celerations Errors, and Improvement Indices

	Continuous Reinforcement				Intermittent Reinforcement			
	I	Ia	II	III	I	Ia	II	III
Correct	÷1.26	x1.06	÷1.08	-1.07	x1.10	÷1.10	÷1.09	÷1.13
Errors	÷1195	÷6.39	÷1.02	x1.09	x2.18	÷51.25	÷1.02	x1.09
Improvement Index	x944	x6.80	÷1.05	÷1.14	÷1.98	x46.52	÷1.07	÷1.23

I "b-d" Discrimination, No Color
Ia Acquisition, Both Letter-Pairs
II Maintenance
III Extinction

major emphasis of this study, an analysis of the effects of reinforcement schedules in maintenance and extinction depended upon subjects learning the discrimination in the acquisition phase.

It seemed necessary to separate results of the acquisition phase into Phase I, results of the "b-d" discrimination training before stimuli were altered, and Phase Ia, results for both letter pairs which were learned by subjects (Table 3). Unfortunately, neither the geometric means in Table 3 nor individual celeration multipliers and improvement indices in Table 4 were representative of the actual performances of subjects, and neither reflect nonlearning (Phase I or Ia). It was found that the nature of the training procedures and the method of recording and analyzing data required a trial-by-trial analysis of the fading session and the two full series sessions to determine if a subject had indeed learned the discrimination. Since the acquisition phase can best be understood in reference to individual data, a more detailed discussion of it will be considered in the section on individual data.

Whereas geometric means for the acquisition phases were not representative of learning, those for the

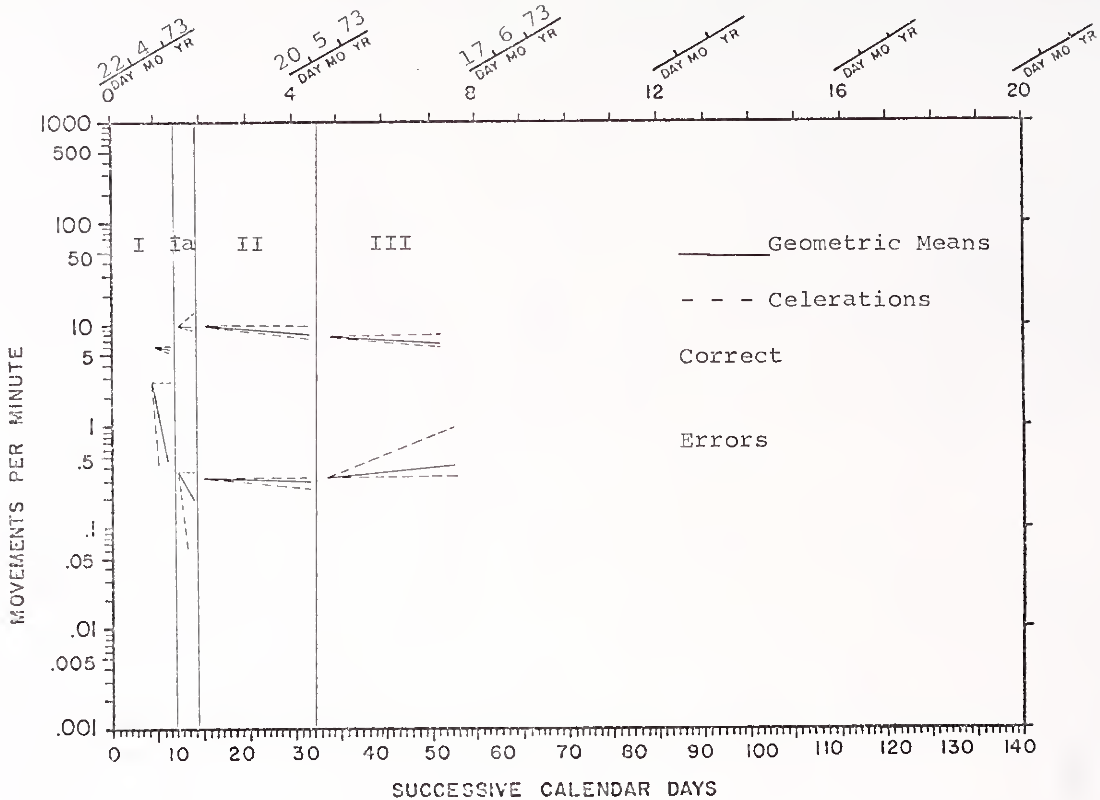


Figure 3. Summary Chart: Geometric Means and Best and Worst Celerations Correct and Errors, Continuous Reinforcement.

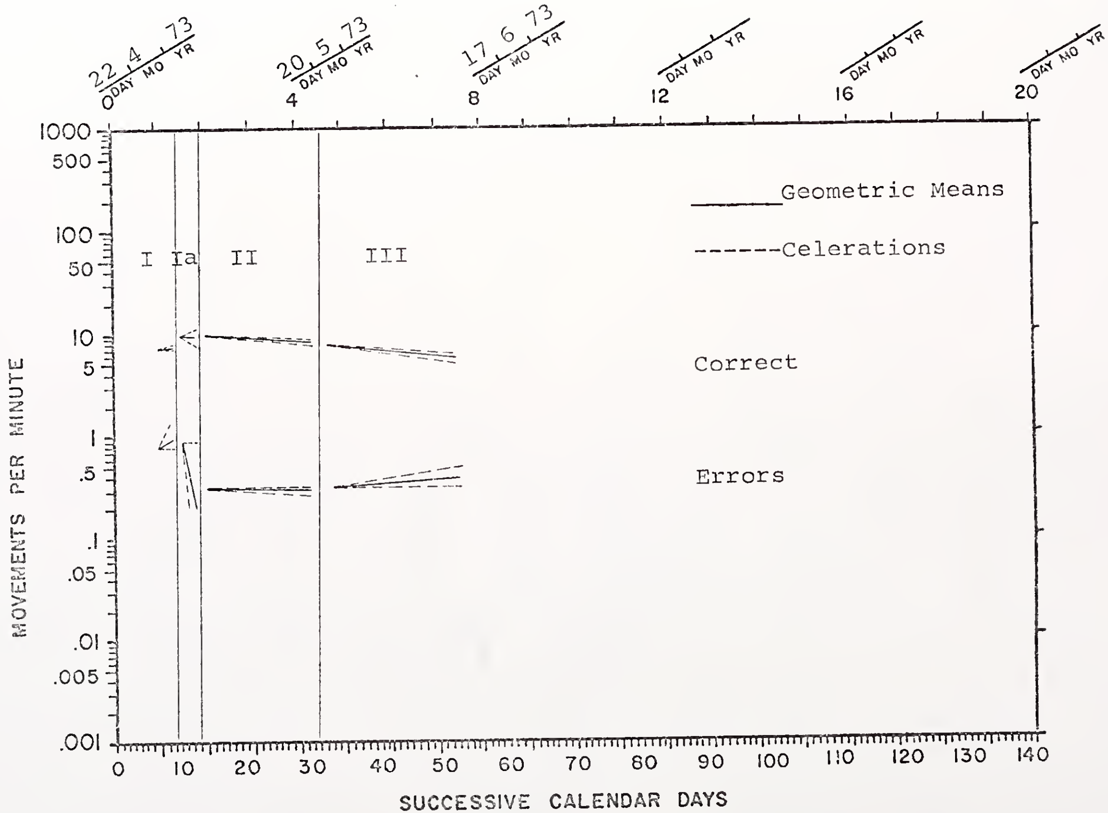


Figure 4. Summary Chart: Geometric Means and Best and Worst Celerations Correct and Errors, Intermittent Reinforcement.

maintenance and extinction phases were representative of the degree to which learning, once it occurred, was maintained. This observation can be more easily verified by reference to Figures 3, 4, 5, and 6. It can be seen that there is considerably more individual variability in Phases I and Ia than in Phases II and III.

Another question of interest in this study was the degree to which each schedule of reinforcement maintained the discriminations once they were learned. Means celeration correct for the maintenance phase were ÷1.08 for the continuous reinforcement schedule and ÷1.09 for the intermittent reinforcement schedule (Table 3). This indicates a slight decrease in frequency of correct responding during the maintenance phase for both schedules, with the difference between them of little practical significance. Reference to Figures 5 and 6 reveals that celeration lines for correct responding during the maintenance phase for both reinforcement schedules cluster closely together and are moving in the same direction.

Means for celeration errors for both the continuous and the intermittent reinforcement schedules were ÷1.02 (Table 3). This indicates a decrease in error frequency during the maintenance phase. Reference to Figures 5 and

6 reveals that celerations for error frequencies were at the record floor, thus representing zero frequency. It can also be seen that for both reinforcement schedules, one subject accounted for the downward trend in errors. The other three subjects in each reinforcement condition had celerations of x1.0, indicating errorless responding throughout the phase.

It should be pointed out at this juncture that Terrace (1963c) demonstrated that there was little difference in the performance and behavior of subjects trained with few errors and those trained with no errors, and thus classified both types of learning as "errorless." The same classification is used in the present study. It should also be noted that when no errors occur, error frequency, reported numerically in Appendix D, Individual Data Sheets, is set at the record floor for purposes of computation. One must either look at total errors or frequency on the Standard Behavior Chart to distinguish between one and no errors rather than at the numerical representation used for computing celerations.

Overall accuracy of responding during the maintenance phase was slightly better for the continuous reinforcement schedule when compared to the intermittent schedule.

Mean improvement index was ÷1.05 for the continuous reinforcement schedule and ÷1.07 for the intermittent schedule (Table 3). This indicates a slight decrease in accuracy for both schedules during the phase. The difference between the schedules was a function of the slightly higher frequency of correct responding in one continuous reinforcement condition.

The question of main concern in the present study was the degree to which accuracy would be disrupted when reinforcement was withdrawn. The trend in the frequency of correct responding in the continuous reinforcement condition showed a slight increase during extinction over that of the maintenance phase. Mean celeration correct was ÷1.07 for the extinction phase as compared to a mean of ÷1.08 for the maintenance phase (Table 3). This trend during extinction was not in the expected direction.

In the intermittent reinforcement condition, correct frequency declined slightly more in extinction than in the maintenance phase, although the difference was not very great. Mean celeration correct for the extinction phase was ÷1.13 and for the maintenance phase was ÷1.09 (Table 3).

A more expected result was found when means of

celerations for error frequencies were compared: the trend for error frequencies increased during extinction in both reinforcement conditions. Mean celeration errors was ÷1.02 in the maintenance phase and x1.09 in the extinction phase for both the continuous and intermittent reinforcement schedules (Table 3). The change was reflected in the mean improvement indices. The mean improvement index of ÷1.14 for the extinction phase of the continuous reinforcement schedule represents a decrease in accuracy when compared with the mean improvement index of ÷1.05 for the maintenance phase (Table 3). There was an even greater decrease in accuracy during the extinction phase of the intermittent reinforcement schedule. Mean improvement index for the extinction phase was ÷1.23 and for the maintenance phase was ÷1.07. These differences in accuracy between the maintenance and extinction phases were a function of the decrease in frequency of correct responding rather than an increase in frequency of errors since means for celerations of error frequencies were the same in both phases for both the continuous and the intermittent reinforcement schedules (Table 3).

The most significant question in this study was

whether or not accuracy would be disrupted during extinction to a greater extent in the continuous reinforcement condition than in the intermittent reinforcement condition as a result of a higher error frequency in the continuous reinforcement condition. Mean celeration for error frequencies for the extinction phase was x1.09 for both the continuous and the intermittent reinforcement schedule, indicating that there was no difference in the degree to which accuracy was disrupted by frequency of errors. Reference to Figure 5 indicates that one subject had an increasing trend in error frequency in the continuous reinforcement condition whereas the other three subjects showed no increase at all. Figure 6 shows that two subjects had an increase in error frequency in the intermittent reinforcement condition while two subjects had no increase at all.

To summarize the results of grouped data, accuracy of responding, as reflected by mean improvement indices, was slightly better for the discrimination trained with continuous reinforcement than for the discrimination trained with intermittent reinforcement during both the maintenance and the extinction phases. The difference was a result of a higher frequency of correct responding

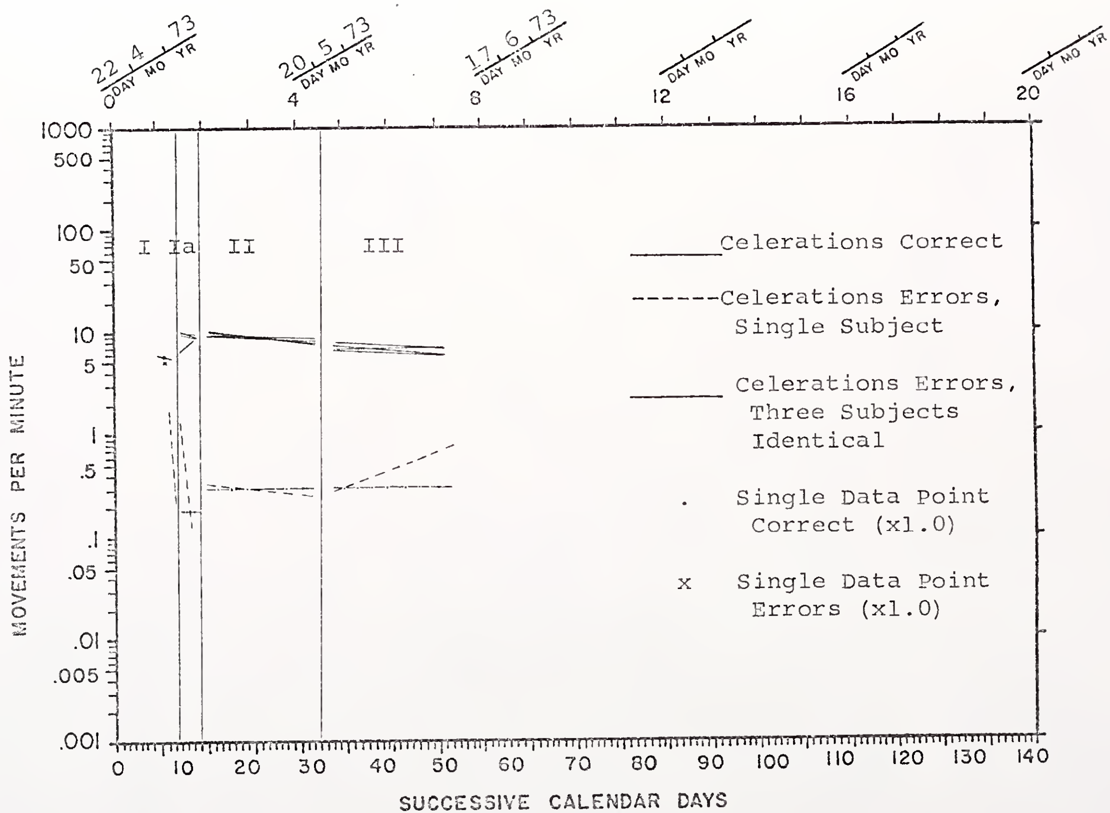


Figure 5. Summary Chart: Celerations Correct and Errors, All Subjects, Continuous Reinforcement

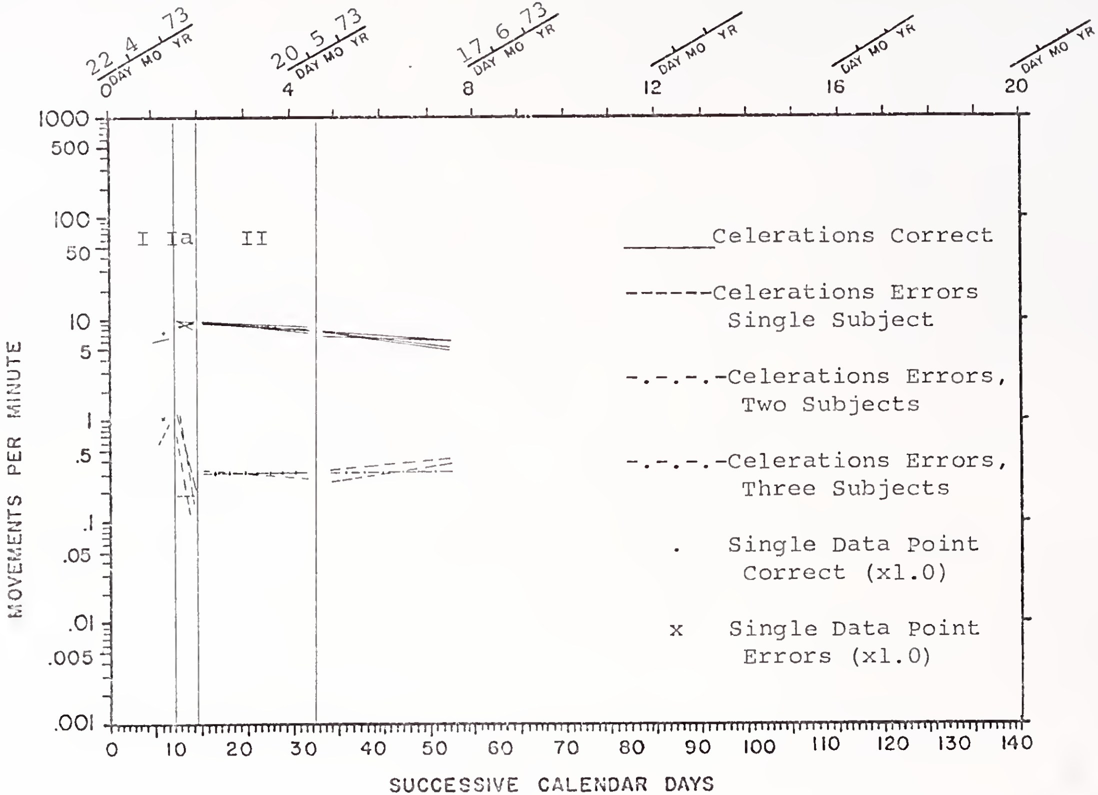


Figure 6. Summary Chart: Celerations Correct and Errors, All Subjects, Intermittent Reinforcement.

in the continuous reinforcement condition during the maintenance and extinction phases inasmuch as error production was the same for both reinforcement schedules although of different values for the two phases.

Frequency of correct responding decreased and frequency of errors increased during extinction for the discrimination trained on the intermittent schedule. However, whereas the frequency of errors increased during extinction for the discrimination trained on the continuous reinforcement schedule, the frequency of correct responding increased over that of the maintenance phase.

Frequency of correct responding decreased and frequency of errors increased during extinction for the discrimination trained on the intermittent schedule. However, whereas the frequency of errors increased during extinction for the discrimination trained on the continuous reinforcement schedule, the frequency of correct responding increased over that of the maintenance phase.

There was no difference between reinforcement schedules in the degree to which accuracy was disrupted during extinction by increased error frequency.

Individual Results

The following analysis of individual results was designed to provide a framework within which to better assess trends of grouped data. A more detailed analysis of results of the acquisition phase will be presented, as well as an analysis of the effects of the change in correction procedures and reinforcement for attending behavior. Phase by phase analysis for each subject will include informal observations which, although not necessarily reflected in the results, nonetheless seemed relevant to the study.

It was mentioned in the first section of this chapter that geometric means for the acquisition phase (Table 3), while they appeared to reflect improvement in some cases, did not accurately represent the learning situation in acquisition. For example, the mean improvement index of x944 for Phase I of the continuous reinforcement condition indicated considerable improvement. A check of Table 4 and Figure 5 will reveal, however, that the large mean improvement index was a result of a decrease in error frequency for Subject 2. Subject 1 had only one correct and one error data point. Even so, neither

subject learned the discrimination during Phase I.

As another example of how these means can be misleading unless reference is made to individual data, the mean celeration correct of x1.06 (Table 3, Phase Ia) of the continuous reinforcement condition showed an upward trend. This trend is the result of Subject 4's performance. The other three subjects had a decrease in frequency of correct responding during this subphase (Table 4, Phase Ia and Figure 5). However, all four subjects learned the discrimination during this phase. These decreases in correct responding as indicated by celerations for Subjects 1, 2, and 3 were probably an artifact of the training procedure and of the decision to include the two full series sessions with the fading session to secure the celerations from which means were derived. Duration of S- exposure was one of the dimensions along which S- was faded. This could have resulted in an inflated frequency of correct responding during the fading session for these subjects. During the full series sessions, duration of S- was at least five seconds, whereas duration varied from one to five seconds in the fading session. Therefore, the increase in S- exposure time for the full series sessions increased the

Table 4

Celerations Correct, Celerations Errors, and Improvement Indices for Each Subject, Each Phase, and Two Reinforcement Schedules

		Continuous Reinforcement				Intermittent Reinforcement			
Subjects		I	Ia	II	III	I	Ia	II	III
1	a	x1.0	÷1.07	÷1.08	÷1.06	---	x1.24	÷1.10	÷1.20
	b	x1.0	÷1666	÷1.09	x1.42	---	÷43.48	x1.0	x1.18
	c	x1.0	x1577	x1.01	÷1.50	---	x53.92	÷1.10	÷1.42
2	a	÷1.59	÷1.42	÷1.07	÷1.10	---	x1.15	÷1.09	÷1.08
	b	÷1428511	x1.0	x1.0	x1.0	---	x1.0	x1.0	x1.0
	c	x892819	÷1.42	÷1.07	÷1.10	---	x1.15	÷1.09	÷1.08
3	a	---	x2.72	÷1.13	x1.04	x1.22	÷1.25	÷1.11	÷1.17
	b	---	x1.0	x1.0	x1.0	x4.77	÷285.70	x1.0	x1.0
	c	---	x2.72	÷1.13	x1.04	÷3.91	x228.56	÷1.11	÷1.17
4	a	---	÷1.41	÷1.04	÷1.07	x1.0	÷1.68	÷1.06	÷1.08
	b	---	x1.0	x1.0	x1.0	x1.0	÷555.55	÷1.08	x1.20
	c	---	÷1.41	÷1.04	÷1.07	x1.0	x330.68	x1.02	÷1.30

a Celeration Correct
b Celeration Errors
c Improvement Index

I "b-d" Discrimination without Color
Ia Acquisition, Both Letter Pairs
II Maintenance
III Extinction

probability that fewer S+'s would be presented, thereby reducing the frequency.

This is not an all-inclusive explanation, however, as witnessed by Subject 4's increase in correct responding during acquisition in the continuous reinforcement condition, as well as that of Subjects 1 and 2 in the intermittent reinforcement condition (Table 4, Phase Ia).

It was assumed in developing stimulus materials for this experiment that the fading dimensions of size, shade, and duration of S- would be sufficient to allow subjects to learn the discrimination with few or no errors. Whereas this was the case for the "P-R" discrimination, it was not so for the "b-d" discrimination. All four subjects had one fading session with the original "b-d" stimulus cards, and Subjects 2 and 3 had two sessions. Frequencies correct and errors for each subject, respectively, were: Subject 1, 6.0 and 5.2; Subject 2, 6.2 and 3.0, 5.8 and 0.4; Subject 3, 6.8 and 0.8, 7.0 and 1.0; Subject 4, 7.4 and 1.2.

These frequencies can be compared with the fading session when color was added to the "b-d" stimuli. Frequencies correct and errors for each subject, respectively,

were: Subject 1, 10.0 and 1.6; Subject 2, 10.4 and 0.2; Subject 3, 9.8 and 1.0; Subject 4, 10.2 and 1.2 (See Appendix D, Tables 5, 7, 10, and 12).

This comparison will reveal that correct frequency increased for all subjects, and error frequency decreased for Subjects 1 and 2 and stayed the same for Subjects 3 and 4. These results, like geometric means and celerations discussed above, while denoting improvement in some cases, still did not show whether or not learning occurred.

The nature of the fading procedure allowed a subject to go through many errorless trials while S+ and S- were easily distinguished by their disparity in terms of fading dimensions. As this discrepancy diminished toward the end of a session, stimuli became more difficult to distinguish. It was possible for a subject to begin making errors at this point, and to do so in a way such as to reveal that he had not learned the discrimination. However, since errors occurred near the end of the session and since many corrects occurred throughout most of the session, a subject could have a high correct frequency and a low error frequency but still not have learned the discrimination.

It is necessary to look at the two full series to get a true indication that subjects learned the discrimination during the fading session. Frequencies correct and errors (with total errors in parentheses) for each subject for the two full series on the "b-d" discrimination, respectively, were: Subject 1, 10.8 and 0.2 (1), 9.8 and 0.2(1); Subject 2, 10.4 and 0.2(0), 9.4 and 0.2(0); Subject 3, 10.8 and 0.2(1), 9.2 and 0.2(0); Subject 4, 8.6 and 0.4(2), 8.8 and 0.2(0). (See Appendix D, Tables 5, 7, 10, and 12.)

The errors that were observed during the two full series sessions, and throughout the remainder of the experiment as well, were qualitatively different than those made in the unsuccessful fading sessions and during the first part of the successful fading sessions. Errors which occurred after the successful fading sessions were caused by "carelessness" or "inattention" or for reasons other than the fact that subjects did not know the discrimination. This was also true for the "P-R" discrimination.

As for the change in the correction procedure, this was done mainly as a result of Subject 4's behavior. It was successful in its purpose in eliminating his "game

playing" behavior which had resulted in two errors during Session 7 of the intermittent reinforcement condition (Appendix D, Table 12). Following the introduction of this contingency, Subject 4 made no more errors until the extinction phase began. This procedure also seemed to have had some effect on Subject 3's error frequency in the intermittent reinforcement condition. There seemed to be no evidence, either in the data or in informal observations, that this procedure had any noticeable effect on the other two subjects.

Candy presented for attending behavior was begun at the same time as the new punishment procedure. Informal observations revealed an immediate effect on attending behavior, although this effect varied during the remainder of the experiment. There may have been an immediate effect on frequency of correct responding in several instances, both when candy was first introduced and when it was withdrawn, although this effect was slight and inconsistent. There seemed to have been no overall effect on trends.

A comparison of frequency of correct responding for the session just prior to the introduction of candy (Session 7 for Subjects 1 and 4 and Session 8 for Subjects 2 and 3) with that of the first session when candy

was given (Session 8 for Subjects 1 and 4 and Session 9 for Subjects 2 and 3) showed that there were four cases where the frequency increased, two cases where it decreased, and two cases where it remained the same (Appendix D, Tables 5-12). This same sort of comparison for the session prior to withdrawal of candy (Session 17 for Subjects 1 and 4 and Session 19 for Subjects 2 and 3) with the session when candy was no longer given showed that there were five cases where the frequency of correct responding decreased and three cases where it increased (Appendix D, Tables 5-12). There was no evidence that candy had any effect on error frequency.

Subject 1

Subject 1 (Table 4; Appendix D, Tables 5 and 6; Appendix E, Figures 7, 8, 15, and 16) had one fading session on "b-d" without color during which he made almost as many errors as he did correct responses. When color was added, Subject 1 learned the discrimination although he had an error frequency of 1.6 (8 errors). A trial-by-trial analysis of errors showed that seven of the errors occurred in the first one-third of the fading session. Subject 1 made only one error in the two full series sessions of the acquisition phase.

Subject 1 had little trouble learning the "P-R" discrimination. He made five times fewer errors during the "P-R" fading session than he did for the unsuccessful "b-d" session.

Sessions 5-17 constituted the maintenance phase during which Subject 1 maintained a low, gradually decreasing error frequency and a slightly decreasing correct frequency for the continuous reinforcement schedule as well as for the intermittent reinforcement schedule.

Extinction began for Subject 1 with Session 18. In the continuous reinforcement condition, Subject 1's error frequency increased (x1.42) although his correct frequency (÷1.06) decreased at a rate more slowly than it had in the maintenance phase. Error frequency also increased in the intermittent reinforcement condition (x1.18). Correct frequency showed a greater decrease (÷1.20) in the intermittent reinforcement condition than in the continuous reinforcement condition. Overall accuracy was slightly better in the intermittent condition (÷1.42) than in the continuous condition (÷1.50).

Subject 1 was consistently more inattentive during the experiment than other subjects and also displayed

much agitated and irrelevant behavior throughout the experiment. He was also the first to express a reluctance to come to sessions, even before extinction began.

In addition to more frequent errors, the effects of extinction were noticeable in other kinds of behavior. There was a considerable increase in irrelevant behavior such as talking to the experimenter, shifting and lying down in his chair, and generally avoiding the task. Subject 1 also asked a number of times why he was getting no more marbles. During Session 24 in the continuous reinforcement condition, Subject 1 was particularly restless. After the seventeenth stimulus presentation, he left his chair and went to explore a filing cabinet in one corner of the basement room. He spent eight minutes with the filing cabinet, then asked to go to the bathroom. He returned in ten minutes to finish the subsession. He then completed the intermittent reinforcement subsession, ending with a correct frequency of 4.66.

One other measure of extinction effects was the number of S+ cards which were re-presented because Subject 1 failed to respond within five seconds of onset. Prior to extinction, only four S+ cards were re-presented to Subject 1, and these were all during Session 17 of

the intermittent reinforcement condition (probability of reinforcement 0.10). During extinction, however, 27 S+ cards were re-presented in the intermittent condition and 19 were re-presented in the continuous condition.

Subject 2

Subject 2 (Table 4; Appendix D, Tables 7 and 8; Appendix E, Figures 9, 10, 17, 18) had two fading sessions on "b-d" without color. Although he showed a considerable reduction in error frequency (3.0 to 0.4) from the first to the second session, analysis of error patterns on a trial-by-trial basis revealed that he had not learned the discrimination. Subject 2 made no errors on the discrimination when color was added, and made no errors during the two full series sessions. He made only one error on the "P-R" discrimination during fading and none during the two full series sessions.

Subject 2's maintenance phase covered Sessions 6-15. He had a gradually decreasing correct frequency (÷1.07) in the continuous reinforcement condition, and made no errors. Correct frequency decreased at a slightly higher rate in the intermittent reinforcement condition (÷1.09), and although Subject 2 made two errors, the celeration was x1.0.

Extinction phase began with Session 16. During extinction, Subject 2 made one error in each reinforcement condition. Correct frequency was slightly higher for the intermittent condition (÷1.08) than for the continuous condition (÷1.10), providing a slightly better overall accuracy for the intermittent reinforcement schedule. Within the intermittent condition, accuracy was better during extinction (÷1.08) than during the maintenance phase (÷1.09).

Subject 2 was a very talkative boy, but responded well to candy. He became aware immediately of the intermittent reinforcement schedule when it was begun in Session 6, and asked a number of times why he got no marble when he said the letter correctly. He was never reluctant to come to sessions, and the major effects of extinction, aside from the slightly lower frequency of correct responses, were an increase in the amount of talking, greater distractability, and an increase in the number of S- cards which had to be re-presented. Ten "b" cards and twenty-one "p" cards were re-presented.

Two incidents occurred during the experiment which had some effect on Subject 2's behavior and performance.

On the day of Session 10, Subject 2's teachers took him home to talk with his parents concerning a discipline problem. He came to his sessions after lunch, and was very restless. Frequency correct for the continuous schedule was 8.66, the first time it had been that low since the two unsuccessful fading sessions. Frequency correct for the intermittent schedule was also 8.66, the lowest it had been since the initial acquisition. He also made the first error he had made since the first session.

Another discipline problem occurred prior to Session 17, and Subject 2 was taken to the principal's office. During his session, he made one error in the continuous reinforcement condition, the first since the two unsuccessful fading sessions. The correct frequency of 6.33 in the intermittent reinforcement condition was the lowest for any session to that time. He also made one error during this session.

Subject 3

Subject 3 (Table 4; Appendix D, Tables 9 and 10; Appendix E, Figures 11, 12, 19, and 20) was the oldest and most attentive of the four subjects. In the continuous reinforcement condition, he made one error

during the fading session and one error during the first full series session, and did not make another error for the remainder of the experiment. In the intermittent condition, Subject 3 received two unsuccessful fading sessions with "b-d" without color, but learned the discrimination when color was added. He made one error during the first full series session, and none during the second.

Sessions 6-15 comprised the maintenance phase. Correct frequency decreased gradually for both the continuous reinforcement schedule (÷1.13) and the intermittent reinforcement schedule (÷1.11). Subject 3 made two errors in the intermittent condition and none in the continuous condition.

Extinction began with Session 16. Contrary to expectations, correct frequency for the continuous reinforcement schedule increased during extinction (x1.04). No errors occurred during this phase for continuous reinforcement. For the intermittent condition, correct frequency of ÷1.17 dropped only slightly more than during maintenance. Three errors occurred in the intermittent condition during extinction. Overall accuracy was better during extinction for the continuous reinforcement schedule.

Subject 3 did not exhibit much restless or irrelevant behavior during the acquisition and maintenance phases. Once extinction began, however, he began to express a reluctance to come to sessions. Eleven S+ stimulus cards had to be re-presented to Subject 3 in each reinforcement condition during extinction.

Subject 4

Subject 4 (Table 4; Appendix D, Tables 11 and 12; Appendix E, Figures 13, 14, 21, and 22) was the only one of the four to learn the "P-R" discrimination with no errors, and made only one error in the continuous reinforcement condition during the entire experiment. Subject 4 had one unsuccessful "b-d" fading session and although he had the same error frequency during the successful as during the unsuccessful session (1.2), he nonetheless learned the discrimination.

Subject 4 had the highest overall correct frequencies for the maintenance phase of all subjects in the continuous reinforcement condition. Although there was a gradual decrease in correct frequency during this phase (÷1.04), the lowest single frequency was 9.33 and most were 10.0 or higher. Correct frequencies were lower for the intermittent reinforcement schedule, and also

showed a gradual decrease during the phase (÷1.06). Two errors occurred during the maintenance phase in the intermittent condition, both during Session 7.

Session 15 marked the beginning of extinction for Subject 4. Correct frequency declined at about the same rate for continuous reinforcement (÷1.07) and for intermittent reinforcement (÷1.08). Overall accuracy was better in the continuous condition (÷1.07) than in the intermittent condition (÷1.30). This was mainly due to the increase in error frequency in the intermittent reinforcement condition of x1.20.

Subject 4 seemed to have been aware of the two different reinforcement schedules to a greater extent than the other three subjects. Once the intermittent schedule was instituted, he stated a preference for the letter "P" over the letter "R." He also reacted with more bizarre and irrelevant behavior during extinction. He avoided looking at cards, slumped in his chair, and frowned a lot. He expressed reluctance to come to sessions, although not as much as Subjects 1 and 3. During Session 21, Subject 4 began making a buzzing sound and drooling early in the first subsession, and continued this throughout the second subsession, stopping only

long enough to call out the correct letter when it was presented. On another occasion, he made small paper balls from a towel, and dropped them on top of the marble container each time he made a correct response. Subject 4 also showed the effects of extinction by having twenty-four "b" cards and seven "P" cards re-presented.

In summary, Terrace (1970) concluded that intermittent reinforcement used during errorless discrimination training in trial conditions maintained accuracy of responding during extinction to a greater extent than did continuous reinforcement. The break-down in accuracy resulted from a large increase in error response following continuous reinforcement. The present study attempted to assess the effects of intermittent and continuous reinforcement on the maintenance in extinction of letter discriminations taught to four kindergarten males using errorless discrimination procedures.

The present study failed to replicate Terrace's results. Results of grouped and individual data revealed little noticeable difference in the degree to which accuracy was maintained in extinction following training with intermittent and continuous reinforcement. The

slight difference in accuracy during extinction in favor of the continuous reinforcement schedule was a function of a difference in frequency of correct responding. Geometric means for error trends in extinction were identical for the two reinforcement schedules. One subject showed a slightly greater increase in error frequency during extinction in the continuous reinforcement condition, while two subjects showed a slightly greater increase in error frequency in the intermittent reinforcement condition.

All subjects had difficulty learning the "b-d" discrimination when fading dimensions were size, shade, and duration of S-. When color was added to both letters, and then gradually eliminated, all subjects learned the discrimination. Subjects had little difficulty in learning the "P-R" discrimination.

During extinction, all subjects exhibited behaviors which were described as "frustrated," including reluctance to come to sessions; restlessness and distractability; and increased failure to respond to S+ in the specified time.

CHAPTER V

DISCUSSION

One of the most extensively investigated and widely accepted findings relative to reinforcement schedules is a phenomenon known as the partial reinforcement extinction effect (Jenkins and Stanley, 1950; Lewis, 1960; Robbins, 1971). This effect is manifested when a partially reinforced response (one which is reinforced according to some probability less than one) occurs more quickly, at a higher rate, or for a longer period during extinction than a continuously reinforced response.

Frustration theory, one of several explanations of the partial reinforcement effect, emphasizes "...classically conditioned (implicit) responses in instrumental learning..." that have "...the capacity to provide feedback stimulation and incentive motivation and to serve as major mediational mechanisms" (Amsel, 1967, p. 6). Frustration theory assumes that when an organism is reinforced for several responses, it develops "reward

expectancy" in the presence of the stimulus cues of the environment in which it was reinforced. Once this expectancy develops, nonreinforcement produces an aversive emotional state called "frustration" which has certain motivational characteristics.

Just as reinforcement produces reward expectancy, nonreinforcement produces "frustration expectancy," or "frustration tolerance." Although a conflict arises because "...the response-produced stimuli accompanying the two anticipatory responses elicit incompatible approach and avoidance tendencies" (Ryan and Watson, 1968, p. 112), it is assumed that the effects of these tendencies generalize and become conditioned to each other. Frustration tolerance can be increased by intermittent reinforcement since nonreward reduces reward expectancy and increases frustration expectancy. This condition should not occur in continuous reinforcement situations.

Terrace (1970) concluded that the disruption of an errorless discrimination trained with continuous reinforcement in trial conditions was a result of frustration generated by the abrupt shift from a high probability of reinforcement in training to zero probability in extinction. Terrace found that accuracy could be maintained during

extinction if the discrimination received some training on an intermittent reinforcement schedule prior to extinction.

The purpose of the present study was to investigate with human subjects the relationship between errorless discrimination training, reinforcement schedules, and the maintenance of accuracy of responding during extinction. Four kindergarten boys were taught two discriminations with separate pairs of alphabet letters. One letter pair received training on a continuous reinforcement schedule and the other received training on an intermittent reinforcement schedule before both letter pairs were put on extinction.

The results of the present study were not consistent with Terrace's (1970) findings. "Frustration" from nonreinforcement in extinction was manifested in a number of behaviors exhibited by subjects. One of these manifestations, however, was not a serious disruption of accuracy as a result of the reinforcement schedule used in training. Trends of grouped data indicated that overall accuracy in extinction was slightly better following continuous reinforcement than following intermittent reinforcement. The difference was a result of a greater decrease in

correct responding for the intermittent schedule since trends in error production were the same for both schedules. Individual results showed two subjects with greater accuracy following intermittent reinforcement and two with greater accuracy following continuous reinforcement. Degree of accuracy was greater for the latter two subjects than for the former two.

One explanation why the results obtained in the present study differed from those found by Terrace (1970) could be that the number of subjects in the present study was so small that these results could have occurred by chance. It would seem, however, that the same could be said for Terrace's results inasmuch as each of his groups contained only three subjects.

An equally valid explanation of the inconsistency of findings could reside in the designs used in the two experiments. Terrace's subjects received training on only one reinforcement schedule whereas subjects in the present study received training on both schedules. Amsel (1967) concluded, on the basis of double-runway experiments with rats, that it was very difficult to demonstrate a within-subject partial reinforcement extinction effect because of generalization of the controlling aspects of stimuli

correlated with the two reinforcement schedules. He cited some evidence to indicate that an effect might be possible if responses were very different or if stimuli were quite different. Both responses and stimuli in the present study were very similar.

LeBlanc (1968) and Crist (1969) suggested that their failure to obtain differences between errorless and trial-and-error procedures in studies with children could have resulted to some extent from the within-subject design wherein each subject got training with both procedures. Terrace (1966) pointed out that a prior history of responding on one discrimination could affect responding on a new discrimination if training were done using the same or similar apparatus.

Pavlik et al. (1965) reported that a within-subject partial reinforcement extinction effect was achieved when the number of responses or reinforcements were equated for a continuous and an intermittent schedule in a study with rats. An earlier experiment had yielded results indicating greater responding in extinction following continuous reinforcement. Pavlik et al. concluded that the partial reinforcement extinction effect was a function of the contingencies employed in their experiments.

The results of these studies suggest that the partial reinforcement extinction effect, while it may not be totally an artifact of the experimental designed used in a study, nonetheless may be highly dependent on the manner and methods of a study. It may be that this effect can be achieved when subjects are isolated from similar and common elements of two treatments thereby screening or blocking generalization. This can be done by using a between-subject design, or by making responses and stimuli so diverse that subjects experience events as being considerably different. To the degree that a subject comes into contact with similar materials and training procedures, to that degree generalization takes place and neutralizes specific effects of different treatments.

Such a conclusion not only questions certain methods of studying behavioral phenomenon, but also raises doubt as to the applicability of results thus obtained. Sidman (1960) questioned the use of group comparisons to control for variables on the assumption that effects of these variables would be unassessable in an individual exposed to several treatments. In the following quotation, Sidman talks about the irreversibility of the effects of repeated exposure of a subject to extinction when trying to

determine the relationship between number of reinforcers and resistence to extinction. By substituting "schedules of reinforcement" for "exposures to extinction," the argument fits well into the present discussion. Sidman contends that where the irreversability of a behavioral process exists it is:

> ...a fundamental property of the behavior that displays it, and cannot be side-stepped....An irreversible behavioral process exists in the individual, and has no continuity from one group of subjects to another...."Uncontaminated" data obtained from separate groups will yield a functional relation that has no counterpart in the behavior of the individual. The function obtained from the individual is a result of an interactive process that extends from one segment of the subject's behavior to another....If it proves impossible to obtain an uncontaminated relation...in a single subject, because of the fact that [schedules of reinforcement] interact with each other, then the "pure" relation simply does not exist. The solution...is to cease trying to discover such a pure relation, and to direct our research toward the behavior as it actually exists. If reversibility does not exist in nature, it does not exist in the laboratory [pp. 52-53].

Sidman's remarks could explain why practices based on experimental results sometimes fail when transferred into the classroom. One cannot assume that results obtained in a highly controlled situation will always hold up in a

loosely controlled learning environment. There may be some "treatments" which can be moved uncontaminated from the research lab into the classroom. The effects of different schedules of reinforcement may not be in this category, however. One would suspect that there are very few instances in everyday classroom settings where a child is shielded from all the interactive influences which abound. If reinforcement effects interact and generalize in tightly controlled experiments, it seems reasonable that the same would be true for a classroom or other learning situation.

If this argument has any validity, then research which investigates the interaction in more natural settings is in order. Where experimental studies are concerned, the question becomes one of deciding which type of design more closely resembles the natural environment of the child. It could be that the environment necessitated by a particular experimental design has no counterpart in the everyday classroom situation. The intent of this argument is not to propose one type of design as being superior to another, but to suggest that effects be assessed by several different methods before their "nature" is determined.

Failure to find a partial reinforcement effect in the present study could be explained from the perspective of social learning theory. Rotter (1966) found that partial reinforcement was more effective than continuous reinforcement in prolonging memory only if the subject perceived reinforcement as occurring as the result of chance factors or factors over which the subject had no control. If the situation were viewed by the subject as one in which skill determined delivery of reinforcement, continuous reinforcement was better. One could only assume that subjects in the present study perceived the delivery of marbles as resulting from their own skills since this was not determined. One could also assume that if subjects perceived delivery of reinforcement to be under their control then no frustration should occur when reinforcement stopped.

One could argue that no differences were found in error output during extinction because both letter pairs were taught using continuous reinforcement during the acquisition phase. The procedures for training and for introducing the intermittent schedule during the maintenance phase followed very closely those used by Terrace (1970). He used a continuous reinforcement schedule in training his subjects, and got a breakdown in accuracy

during extinction due to a substantial increase in errors. In the present study, a partial reinforcement extinction effect might have been obtained had the intermittent schedule been introduced earlier in training before the discrimination was learned. This is a testable hypothesis which must await further study.

There may be some very fundamental differences in the way members of various species come under the control of the stimuli used in discrimination tasks. Terrace (1966) and Leith and Haude (1969) have discussed the possibility of species-specific mechanisms operating to produce differences in what is learned and how in studies with animals. It is very possible that the "mechanisms" underlying human learning would preclude the reversability during extinction of the stimulus control achieved during training of a discrimination. This could be particularly true in verbal tasks in which the response is naming the S+.

Observations of subjects in this study led the experimenter to conclude that learning of the discrimination was an "all-or-nothing" affair. That is, one could pinpoint with great certainty the particular trial which marked the "before and after" point of "knowing." Errors

which occurred after this point were qualitatively different from those made before it, and were mainly "frustration errors." This type of error was very apparent during the latter stages of the maintenance phase and during the extinction phase. It was as if subjects were "getting back" at the experimenter by being wrong when no reinforcement was forthcoming after a response. Even then, however, errors were few and sporadic in relation to the number of correct responses.

It is quite possible that the number of trials given to subjects allowed them to learn the discrimination so well that they would not have made many errors in extinction regardless of the reinforcement schedule used in training.

The present study confirmed findings of other studies that fading procedures can be extremely effective in minimizing errors in learning a discrimination. In analyzing the data relative to the acquisition of the discriminations for both letter pairs, it is apparent that the most important independent variable in the present study was the fading process. In addition, certain results of this study confirmed findings of Terrace (1966) that one cannot make *a priori* decisions about the dimensions

to be faded and expect to be totally successful. This point is clearly emphasized by the need to alter the "b-d" stimulus cards by adding color. The four subjects in the study learned the discrimination when this was done.

The experimenter's curiosity led him to attempt to train two other kindergarten boys on the "b-d" discrimination with the color cue added. Neither of these boys learned the discrimination although each was given three fading sessions. It was found that each of these boys was responding to the color cue on the "b." As soon as the color disappeared, performance broke down. It was assumed that the step from the last "b" with color to the first "b" with no color was small enough to allow the subjects to make the transition with no trouble. Color on the last "b" was a barely discernable dot no larger than the period at the end of this sentence. However, when it was missing, neither subject was able to tell a "b" from a "d." Neither reinforcement nor punishment procedure had any positive effects.

These observations, in Terrace's (1966) words, "... should again remind us that the discriminative stimuli varied by the experimenter often provide an incomplete picture of the controlling stimuli" [p. 316]. Sidman

and Stoddard (1967) pointed out that just designating particular variables as being relevant to one's methodology does not make them so. Rather, every training technique carries with it an inherent reinforcement contingency which can conflict with other contingencies to produce errors. Results of the present study illustrate this point perfectly.

Observations of subjects at the beginning of this experiment showed them to be eager to comply with the requirements of the tasks as long as they were able to do so. When a task became difficult, as the "b-d" discrimination without color proved to be, subjects sought ways to solve the problem, or at least to maximize their success probability. Unfortunately, certain aspects of the experimental procedures especially designed to prevent adventitious reinforcement of inappropriate behavior had the opposite effect. In the "b-d" fading session before the color was added, two correction procedures interacted to interfere with learning.

If a subject failed to respond within five seconds of S+ onset, it was re-presented as the next trial. When a response occurred in the presence of S-, a marble was taken and S- was presented as the next trial. This punishment procedure had the effect on Subjects 2 and 4 of suppressing

not only responses to S- but those to S+ as well. Subjects were able to make correct responses and to avoid errors with considerable success by observing the cue provided by the re-presentation of stimulus cards. The subject would sit quietly when a card was presented. No response to S- terminated it and led to the presentation of the next card. By not responding when S- was presented, the subject was able to avoid losing a marble. No response to S+ also resulted in its removal, but it was then re-presented. Subjects 2 and 4 learned to say "b" only when a stimulus card was re-presented, thereby performing as if they knew the discrimination perfectly. However, rather than being under the stimulus control of the distinctive features of the appropriate letter, they were under the control of the correction procedure.

When color was added and subjects were able to progress through the fading session with greater success, Subjects 2 and 4 abandoned this pattern of responding. Terrace (1966) had concluded that for pigeons once responding to S- began it could not be stopped even when the values of the discriminative stimuli were radically changed. This did not seem to be the case with kindergarten boys in the present study.

This problem probably could have been avoided had stimuli and procedures been electronically programmed and presented. In the present study, subjects were able to see the experimenter, and, thus, knew when a card was being re-presented. This finding should have particular relevance to those who teach children in similar situations without the availability of sophisticated equipment. It emphasizes the point that, in face to face situations with pupils, teachers must be aware that almost any behavior they exhibit may gain control over responding and must take steps to ascertain that pupil performance is being controlled by the stimuli the teacher intended. Children sometimes learn what we do not intend from procedures designed to teach them other things, and they do so with great success.

Examination of the results relative to the "b-d" discrimination raises questions about what is learned in a discrimination task, how it is learned, and what part reinforcement plays in that learning. Gay and Stephenson (1972) have stated:

> It seems reasonable to entertain, as a tentative hypothesis, the possibility that perceptual processes directly control learning and that the role of reinforcement is to effect the motivation

> and, in most cases, to determine for the learner what characteristics or stimuli will be treated as relevant [p. 48].

Guralnick (1972) proposed that discrimination learning is a two-stage process. The first is a perceptual process whereby the subject discriminates and attends to the relevant dimensions of a stimulus. The second is an associational process whereby an appropriate instrumental response becomes attached to the relevant stimuli through a process of reinforcement. Failure to learn a letter discrimination might result from poor perception of relevant dimensions, or from lack of association between clearly perceived graphic forms and their verbal responses.

In the present study, the problem subjects had in learning the "b-d" discrimination before color was added appeared to be a perceptual one, particularly since neither punishment nor reinforcement seemed to be very effective until subjects became initially aware of the distinctive features of the stimuli. Once this awareness occurred, however, it was the confirmatory role of reinforcement which led to continued success in learning. An inconsistent schedule of reinforcement would probably have interfered greatly with smooth progress.

Further evidence for the importance of perception comes from a follow-up of the two pupils not in the study who failed to learn the color-cued "b-d" discrimination. Each pupil was given specific instruction as to what the distinctive feature of each letter was (the "hump") and its position relative to the stem. After a few minutes of such instruction, each pupil was given several full series trials with no errors.

Although these results were not obtained under strictly controlled conditions, they do raise enough questions to suggest a profitable line of research. It could be that specific instruction of distinctive features would result in more effective and efficient learning for some subjects than would a fading approach. A combination of these two approaches might produce optimal results. This would provide for preliminary training of distinctive features of S+ followed by discrimination training with S- faded in. A similar method has been suggested by Guralnick (1972).

In line with Guralnick (1972) and Gay and Stephenson (1972), the results of this experiment seemed to indicate a dual role for reinforcement: confirmation and motivation. Both roles were apparent when subjects were first

learning the discriminations. As training progressed, the confirmatory role diminished while the motivational role continued.

The motivational nature of reinforcement is most relevant to the frustration hypothesis set forth by Terrace (1970) to explain the breakdown in responding in extinction following continuous reinforcement in training. As has already been discussed, frustration resulting from nonreinforcement in extinction in the present study had little effect on the accuracy of the discriminations. However, frustration was manifested in much adjunctive behavior of subjects.

Subjects were reluctant to come to sessions; were slower to respond to S+; avoided looking at the display slot where cards were shown; and exhibited signs of increased restlessness and distractibility. Regardless of the high degree of avoidance behavior; once subjects attended to the display slot and stimuli were presented, few errors occurred. This suggests that nonreinforcement, rather than directly causing learning to deteriorate, produces other behaviors which are incompatible with a consistent expression of that learning.

Implications

There is always the danger of overgeneralization as one attempts to move from research to application, and to proclaim more than the data will support. On the other hand, an experimenter, on the basis of close, day-to-day contact with the experimental situation, feels compelled sometimes to speculate about factors which the data do not readily reveal. It would seem, then, that a most important responsibility of an experimenter when making suggestions to others about applying the findings of a particular study is that he delineate those which are based on the data and those which are mainly speculation.

In attempting to point out something from the present study which might prove helpful to those concerned with more efficient and effective methods of discrimination training, it must be stated that all suggestions must be viewed within the perspective of the framework of this particular study. Anyone attempting to base classroom practice upon either the findings of particular procedures of this study must be cognizant of all the factors which interacted to produce the results herein reported (to the degree that these factors can be known). These factors include the nature and number of subjects, the type of

materials and apparatus, and the specificity of the methods and procedures used in this study. Furthermore, each subject in this study was taught in a one-to-one tutoring situation, and nothing in this study should be construed as suggesting applicability of these procedures in group situations.

The results of this study do not justify a statement concerning the superiority of one reinforcement schedule over another in errorless discrimination training with the four subjects involved. Once a discrimination was learned, both schedules were relatively effective in maintaining accuracy during maintenance and extinction. This is not to say that no differences exist in the degree to which different schedules of reinforcement maintain a discrimination taught with errorless procedures, but that in this study none was found.

There are a number of findings relative to the acquisition of the discriminations in this study which should be reinterated. It was found in attempting to teach the four subjects letter discriminations with errorless procedures that one letter pair ("b-d") was much more difficult for them to learn than the other letter pair ("P-R"). Dimensions which the experimenter considered

relevant in creating the stimuli were not necessarily so in the actual learning situations. However, the more difficult letter pair was learned when color was added to highlight what were considered the "distinctive features" of the two difficult letters. Even then, color was not enough to allow two boys not involved in the main experiment to learn the "b-d" discrimination. Neither reinforcement nor any of the correction procedures were effective in helping these two to learn the discrimination.

When errors were occurring early in training in this study, all four subjects were more susceptible to development of error patterns maintained by various experimental procedures. Some behavior of subjects came under the control of variables in a way which was quite unintended. When subjects were successful in making responses which led to reinforcement, they abandoned these error patterns.

It was found that marbles which could be exchanged for pennies proved to be reinforcing to the subjects in this study. Candy was effective for maintaining attending behavior. Use of these particular "reinforcers" does not preclude the effective use of other such subsequent events in similar studies. A reinforcer is defined in

terms of its functional relationship to the particular behavior in question, and cannot be assumed a priori to be effective.

Once the discriminations were learned, accuracy remained relatively high even when reinforcement was withdrawn. While removal of reinforcement did not greatly affect accuracy, other behavior, which can be classified as "frustrated," occurred in the case of all four subjects. This behavior somewhat resembled that displayed when subjects were making errors early in training.

As stated earlier, an experimenter sometimes feels compelled to speculate about implications the results of a study might have. The following comments are tentative and are intended to serve as caution signs for anyone attempting to use errorless procedures similar to those of the present study. These suggestions are derived from this study and from the findings of others involved in errorless discrimination training research.

In deciding what features of a stimulus to fade, one must not assume that what he considers as the relevant features will be the ones to which the child will attend. One must be attentive not only to each response the child makes, but to the pattern of responding, particularly if

errors are occurring. It is only by close observation on a trial-by-trial basis that one can ascertain to what the child is responding. By realizing that many things other than those intended can gain control over a child's behavior during a training situation, particularly if the child is unsure of the instructions or if he is making many errors, one can guard against assuming that learning has occurred when in fact it has not. The behavior of the trainer as well as other aspects of the environment can become cues for responding which have little to do with the relevant features of a particular stimulus.

Awareness of the two-stage concept of discrimination proposed by Guralnick (1972) would also seem beneficial to the teacher in discrimination training situations involving the naming of graphic symbols such as alphabet letters. This concept involves a perceptual process whereby the child discriminates and attends to the distinctive features of a stimulus, and an associational process whereby an appropriate response becomes attached to the relevant stimuli through a process of reinforcement. Recognition of the interaction of perception with reinforcement should better enable the teacher to understand one reason why a child might not learn the names of letters. Failure might

result because the task is so difficult that relevant features are not distinguished. Or it could be that the child perceives the relevant features, but because of the inconsistency of reinforcement, the association thus developed is poor. The failure of a child to obtain reinforcement because of poor perception or because of a faulty reinforcement schedule even when perception is good might also provide alternatives for understanding "emotional" or "frustrated" behavior encountered in some learning situations.

One should not assume that errorless discrimination training is the only way, nor in fact the most efficient way, to train all discriminations or every child. Many children are able to learn in very conventional ways. However, this procedure might be of special benefit for those children suspected to have learning difficulties or who have demonstrated a lack of motivation to engage in learning tasks. It should be stated, however, that in making decisions concerning instructional tasks and procedures, the most important variable to be considered by the teacher is the behavior of the individual child.

Suggestions for Future Research

Although the results of the present study were not consistent with the findings of Terrace (1970), they were similar to those of other researchers (Amsel, 1967). One major question raised by this discrepancy is the extent to which the results of the present experiment were a function of the small number of subjects used. Would a larger number of subjects yield a more consistent result? Since the number of subjects was small in this and in Terrace's (1970) study, the most reasonable solution would be a replication of the present study using a larger number of subjects and employing both within-subjects and between-subjects designs. One group of subjects could receive training under continuous reinforcement conditions, another could receive training under intermittent reinforcement conditions, and a third could receive training under both conditions. One might also employ inferential statistics in making comparisons.

In addition to the variations just discussed, a number of other variables should be investigated, including different intermittent schedules, types of reinforcement, letter pairs, and subjects. There is the possibility

that the type of response required of subjects in the present study influenced the results. This should be investigated by comparing results obtained requiring verbal and nonverbal responses in the presence of S+.

A further line of research which could be fruitful would be an investigation of the relationship among errorless discrimination training, reinforcement schedules, and Rotter's (1966) internal-external locus of control of reinforcement dimension.

The method for calculating frequency in this study, while it provided for a seemingly valid and sensitive measure of accuracy, did not reflect the effects of nonreinforcement manifested in other behaviors. One way to do this would be to get a real time measure of subsession length and a net time measure of stimuli exposure within a subsession. The ratio of these two might provide a suitable index by which to gauge the relative effects of different reinforcement schedules during maintenance and extinction. Frequency counts of "frustration" behavior could be compared to measures of accuracy and the real time-net time index as an additional assessment of schedule effects. Frequency counts could be obtained from video tapes of sessions or by a live observer.

This study revealed that a high degree of control could be achieved without the use of expensive electronic programming and recording equipment, although stimulus cards were commercially produced. Further study should focus on the degree to which handmade cards could be used. Many materials used by children in school are teacher-made. It could be that, while sophisticated programming equipment allows for greater experimental control in research studies, teachers would more readily apply research findings which were produced by methods and equipment easily obtainable and simple to use. More research should be done in which results gained by elaborate and simple methods are compared. If the latter provided comparable results, there is reason to suspect greater applicability in classroom settings.

CHAPTER VI

SUMMARY AND CONCLUSIONS

Since an earlier study by Terrace (1970) had indicated that the type of reinforcement schedule used during errorless discrimination training in trial conditions could affect response accuracy during extinction, this study was undertaken to examine whether or not continuous and intermittent reinforcement used with errorless discrimination training of alphabet letters would have a differential effect on responding during extinction of four Black kindergarten boys.

A within-subject design permitted each subject to receive training on two pairs of alphabet letters: "b-d" and "P-R." The first letter of each pair was correlated with reinforcement (S+), and the second letter in each pair was correlated with nonreinforcement (S-).

The acquisition phase of training consisted of one fading session and two full series sessions. Letters printed on cards were shown to the subject one at a time

in a random sequence. In the fading session, S- was initially larger and lighter than S+, and was exposed for shorter periods of time. Throughout the session, S- was gradually changed until it was like S+ except in the distinguishing feature, and was exposed for a constant length of time. The subject was required to name S+ when it was presented, and to say nothing when S- was presented. Marbles exchangeable for pennies were delivered following correct responses. Several correction procedures operated when errors occurred. Letters in the two full series sessions were identical except in the distinctive feature. Subjects were trained individually by the experimenter in the basement room of an elementary school over a six-week period.

It was necessary to alter the "b-d" letters when subjects were unable to learn the discrimination when size and shade were the only faded dimensions. Color was added to these letters, and gradually eliminated in successive trials, thus allowing all subjects to learn the discrimination with few errors.

One pair of letters for each subject was maintained on a continuous reinforcement schedule and the other pair was gradually switched to an intermittent schedule during

a maintenance phase. Under the latter condition each subject received one session with the probability of reinforcement at 0.75, two sessions at 0.50, and one session at 0.25. Subjects 2, 3, and 4 received six sessions with the probability of reinforcement at 0.10, and Subject 1 received nine sessions at 0.10. Attending behavior was reinforced with candy on a time basis during the maintenance phase.

Reinforcement was withdrawn during the extinction phase. Subject 1 received eight extinction sessions; Subject 2 received nine; Subject 3 received eleven; and Subject 4 received ten.

Frequency of responding was the basic datum in this experiment. Frequencies were calculated by dividing the number of correct responses and errors by the amount of S+-S- exposure time in each subsession, and were recorded daily on Standard Behavior Charts for each subject and each reinforcement schedule. Once the experiment was completed, celerations were calculated from frequencies in each phase to provide measures of change in frequencies over time. An improvement index, which represents the degree of accuracy maintained over time, was derived by the ratio of the correct to the error celerations in each

phase. Trends of grouped data were obtained by calculating geometric means of the celerations and improvement indices of all four subjects.

Analysis of grouped data revealed little noticeable difference in the effectiveness of continuous and intermittent reinforcement to maintain in extinction a discrimination taught with errorless procedures. Accuracy of responding was slightly better under the continuous than under the intermittent reinforcement schedule for both the maintenance and extinction phases. The difference was a result of higher frequencies of correct responding under the continuous as compared to the intermittent reinforcement condition. Error trends were identical for the two reinforcement schedules in the maintenance and extinction phases. However, the values of the trends were different for the two phases, with the extinction phase showing an increase in error output. In a comparison of the maintenance and extinction phases, it was found that frequency of correct responding decreased and frequency of errors increased during extinction for the intermittent schedule. However, whereas the frequency of errors increased during extinction under the continuous reinforcement condition, the frequency of correct responding increased slightly over that of the maintenance phase.

Individual results indicated that Subjects 1 and 2 had slightly better accuracy during extinction under the intermittent condition, and Subjects 3 and 4 had slightly better accuracy under the continuous condition. Subject 1 showed a slight increase in error production under both reinforcement conditions, and Subject 4 showed a similar increase under the intermittent condition. Subject 3 had slightly better overall accuracy during extinction than during maintenance under the continuous reinforcement condition, and Subject 2 had similar results for the intermittent schedule.

Informal observations revealed that all subjects exhibited certain "emotional" or "frustration" behavior during the extinction phase. This was reflected in subjects' reluctance to come to sessions; inattentiveness and avoidance of the tasks; restless and agitated movements during sessions; and an increase in the number of S+ cards which had to be re-presented because subjects failed to respond in the allotted time.

Several explanations were suggested to account for the failure of the results of this study to fit consistently with those of Terrace (1970). It could have been that the number of subjects in this study was too small

to reflect differences between the two schedules. It was also possible that the within-subject design of the present study prevented the manifestation of the partial reinforcement extinction effect due to generalization of the controlling aspects of stimuli correlated with the two reinforcement schedules. In addition, Rotter (1966) has suggested that whether a subject perceived reinforcement as controlled by his own skill or by chance factors could influence his responding on continuous and intermittent schedules. Finally, the procedures used in the present study might not have been appropriate for the establishment of the partial reinforcement extinction effect.

Results of the acquisition phase of this study confirmed findings of other studies that fading procedures can be effective in reducing errors in discrimination learning situations. The need to alter the "b-d" letters also confirmed Terrace's (1966) conclusion that the experimenter cannot always be certain that those features of a stimulus he considers appropriate for fading will necessarily result in errorless learning by the subject. Perceived distinctiveness of stimuli must be established empirically when a subject does not respond appropriately to features determined relevant by the experimenter.

Observations of subjects' unexpected reactions to other experimental methods, such as the correction procedures, emphasized the point made by Sidman and Stoddard (1967) that methods intended to facilitate learning can themselves often produce contingencies which interfere with learning.

Future research might include a comparison of schedule effects on the maintenance in extinction of discriminations trained with errorless procedures in a study incorporating both within-subject and between-subject designs utilizing a larger sample and inferential statistical methods. Other variables which could also be investigated are different intermittent schedules, types of reinforcement, letter pairs, and subjects. In addition, an examination of the relationship among errorless discrimination, reinforcement schedules, and Rotter's (1966) internal-external locus of control of reinforcement dimension might be fruitful.

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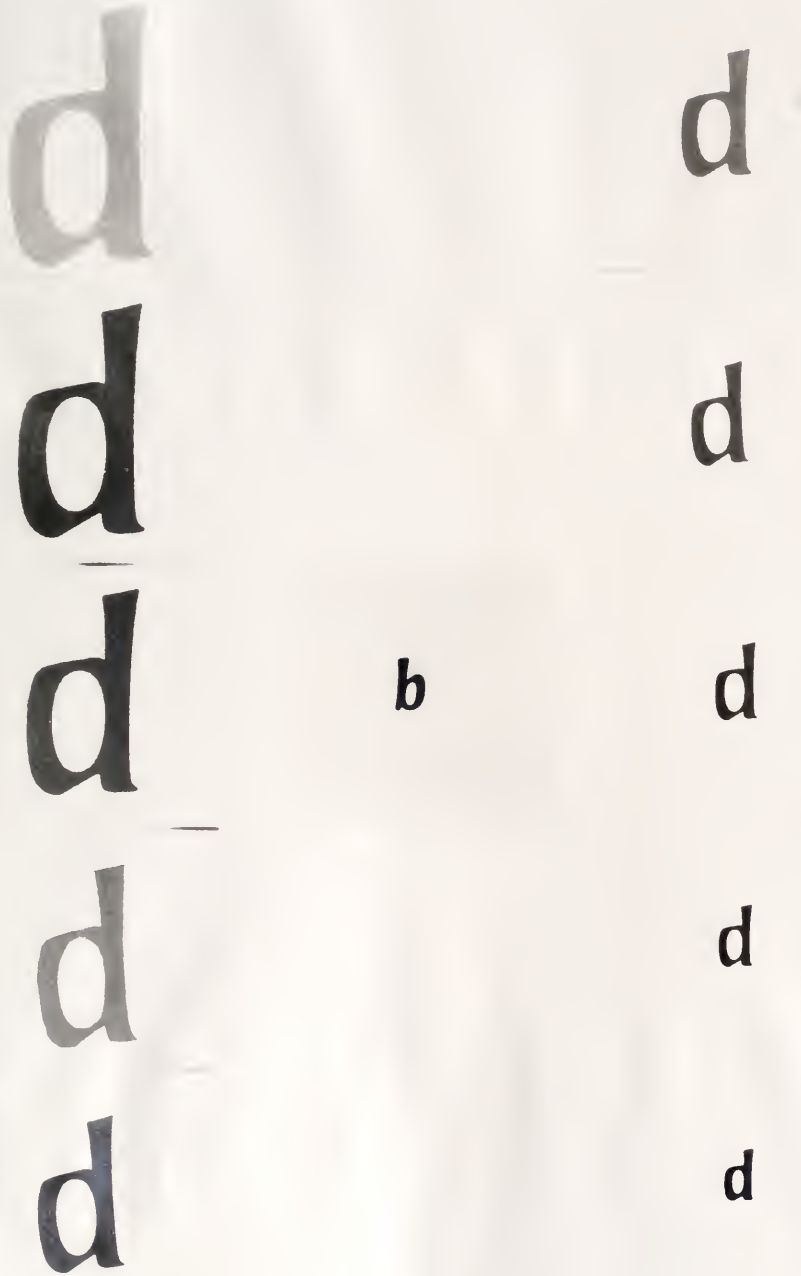
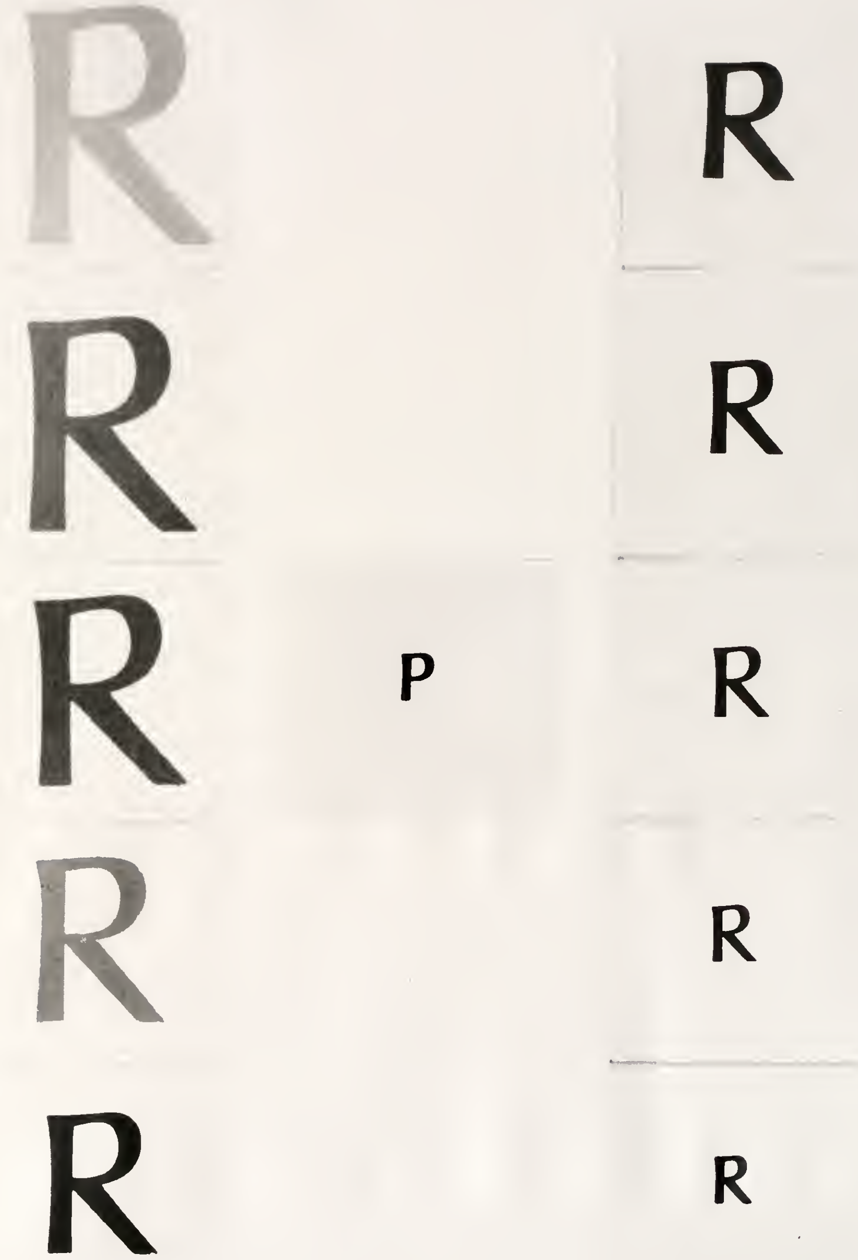
APPENDICES

APPENDIX A

SAMPLE STIMULUS CARDS, FADING SERIES



Sample Stimulus Letters, Fading Series



Sample Stimulus Letters, Fading Series

APPENDIX B

RANDOMIZED ORDER OF PRESENTATION OF LETTER PAIRS CORRELATED WITH REINFORCEMENT SCHEDULES

Randomized Order of Presentation of Letter Pairs
Correlated with Reinforcement Schedules

Session	First Subsession	Second Subsession	Session	First Subsession	Second Subsession
1	CRF	INT	14	INT	CRF
2	CRF	INT	15	CRF	INT
3	INT	CRF	16	CRF	INT
4	INT	CRF	17	INT	CRF
5	CRF	INT	18	INT	CRF
6	INT	CRF	19	CRF	INT
7	CRF	INT	20	INT	CRF
8	INT	CRF	21	CRF	INT
9	CRF	INT	22	CRF	INT
10	INT	CRF	23	INT	CRF
11	CRF	INT	24	CRF	INT
12	INT	CRF	25	INT	CRF
13	CRF	INT	26	INT	CRF

CRF: Continuous Reinforcement; INT: Intermittent Reinforcement

APPENDIX C

RESPONSE RECORD SHEET

Response Record Sheet

Letter Pair: S- ___ S- ___ Reinforcement Schedule ______________

Date ______________ Subject ______________ Order 1 2 (Circle One)

First Present.	Repeat	First Present.	Repeat	First Present.	Repeat	First Present.	Repeat
1. ____	____	26. ____	____	51. ____	____	76. ____	____
2. ____	____	27. ____	____	52. ____	____	77. ____	____
3. ____	____	28. ____	____	53. ____	____	78. ____	____
4. ____	____	29. ____	____	54. ____	____	79. ____	____
5. ____	____	30. ____	____	55. ____	____	80. ____	____
6. ____	____	31. ____	____	56. ____	____	81. ____	____
7. ____	____	32. ____	____	57. ____	____	82. ____	____
8. ____	____	33. ____	____	58. ____	____	83. ____	____
9. ____	____	34. ____	____	59. ____	____	84. ____	____

Response Record Sheet (Continued)

First Present.	Repeat	First Present.	Repeat	First Present.	Repeat	First Present.	Repeat
10. ____	____	35. ____	____	60. ____	____	85. ____	____
11. ____	____	36. ____	____	61. ____	____	86. ____	____
12. ____	____	37. ____	____	62. ____	____	87. ____	____
13. ____	____	38. ____	____	63. ____	____	88. ____	____
14. ____	____	39. ____	____	64. ____	____	89. ____	____
15. ____	____	40. ____	____	65. ____	____	90. ____	____
16. ____	____	41. ____	____	66. ____	____	91. ____	____
17. ____	____	42. ____	____	67. ____	____	92. ____	____
18. ____	____	43. ____	____	68. ____	____	93. ____	____
19. ____	____	44. ____	____	69. ____	____	94. ____	____
20. ____	____	45. ____	____	70. ____	____	95. ____	____
21. ____	____	46. ____	____	71. ____	____	96. ____	____

Response Record Sheet (Continued)

First Present.	Repeat	First Present.	Repeat	First Present.	Repeat	First Present	Repeat
22. ______	______	47. ______	______	72. ______	______	97. ______	______
23. ______	______	48. ______	______	73. ______	______	98. ______	______
24. ______	______	49. ______	______	74. ______	______	99. ______	______
25. ______	______	50. ______	______	75. ______	______	100. ______	______

Total Correct__________ FREQ. __________ Total Errors __________ FREQ __________

APPENDIX D

TABLES OF INDIVIDUAL DATA SHEETS

Table 5

Data Sheet

SUBJECT 1 S+: b S-: d Continuous Reinforcement

Date	Session #	Total S+-S-	Total S+	Correct S+	Freq. Correct	Total S-	Errors	Freq. Err.	Time	Floor
4-30	--	--	--	--	--	--	--	--	--	--
5-1	1	87	31	30	6.0	56	26	5.2	5.0	.20
5-2	2	108	50	50	10.0	50	8	1.6	5.0	.20
5-3	3	108	54	54	10.8	54	1	0.2	5.0	.20
5-4	4	99	49	49	9.8	50	1	0.2	5.0	.20
5-7	--	--	--	--	--	--	--	--	--	--
5-8	5	58	30	29	9.66	28	0	0.33	3.0	.33
5-9	6	58	28	27	9.0	30	2	0.66	3.0	.33
5-10	7	53	26	26	8.66	27	1	0.33	3.0	.33
5-11	8	57	29	29	9.66	28	0	0.33	3.0	.33
5-14	9	56	28	28	9.33	28	0	0.33	3.0	.33
5-15	10	51	26	26	8.66	25	1	0.33	3.0	.33
5-16	11	50	25	25	8.33	25	0	0.33	3.0	.33
5-17	12	51	25	25	8.33	26	0	0.33	3.0	.33
5-18	13	50	26	23	7.66	24	0	0.33	3.0	.33
5-21	--	--	--	--	--	--	--	--	--	--
5-22	14	51	25	24	8.0	26	1	0.33	3.0	.33
5-23	15	50	25	25	8.33	25	1	0.33	3.0	.33
5-24	16	50	25	25	8.33	25	0	0.33	3.0	.33
5-25	17	46	23	22	7.33	23	1	0.33	3.0	.33
5-28	18	45	23	20	6.66	22	1	0.33	3.0	.33
5-29	19	46	25	21	7.0	21	0	0.33	3.0	.33
5-30	20	44	25	20	6.66	19	0	0.33	3.0	.33

Table 5 (Continued)

SUBJECT 1 S+: b S-: d Continuous Reinforcement

Date	Session #	Total S+-S-	Total S+	Correct S+	Freq. Correct	Total S-	Errors	Freq. Err.	Time	Floor
5-31	21	39	19	17	5.66	20	3	1.0	3.0	.33
6-1	22	43	22	19	6.33	21	1	0.33	3.0	.33
6-4	23	42	22	16	5.33	20	1	0.33	3.0	.33
6-5	24	43	23	18	6.0	20	2	0.66	3.0	.33
6-6	25	43	21	21	7.0	22	2	0.66	3.0	.33

Table 6

Data Sheet

SUBJECT 1		S+: P	S-: R		Intermittent Reinforcement					
Date	Session #	Total S+-S-	Total S+	Correct S+	Freq. Correct	Total S-	Errors	Freq. Err.	Time	Floor
4-30	--	--	--	--	--	--	--	--	--	--
5-1	1	93	45	44	8.8	48	5	1.0	5.0	.20
5-2	2	100	49	49	9.8	51	3	0.6	5.0	.20
5-3	3	--	--	--	--	--	--	--	--	--
5-4	4	97	49	49	9.8	48	0	0.2	5.0	.20
5-7	--	--	--	--	--	--	--	--	--	--
5-8 (.75)	5	58	29	29	9.66	29	0	0.33	3.0	.33
5-9 (.50)	6	60	30	30	10.0	30	0	0.33	3.0	.33
5-10(.50)	7	59	29	28	9.33	30	1	0.33	3.0	.33
5-11(.25)	8	56	28	28	9.33	28	0	0.33	3.0	.33
5-14(.10)	9	57	29	29	9.66	28	0	0.33	3.0	.33
5-15(.10)	10	53	27	27	9.0	26	0	0.33	3.0	.33
5-16(.10)	11	23	23	23	7.66	24	0	0.33	3.0	.33
5-17(.10)	12	50	25	25	8.33	25	0	0.33	3.0	.33
5-18(.10)	13	44	21	21	7.0	23	0	0.33	3.0	.33
5-21	--	--	--	--	--	--	--	--	--	--
5-22(.10)	14	52	26	26	8.66	26	0	0.33	3.0	.33
5-23(.10)	15	53	26	26	8.66	27	0	0.33	3.0	.33
5-24(.10)	16	51	25	25	8.33	26	1	0.33	3.0	.33
5-25(.10)	17	47	25	21	7.0	22	0	0.33	3.0	.33
5-28	18	44	25	20	6.66	19	0	0.33	3.0	.33
5-29	19	50	26	23	7.66	24	0	0.33	3.0	.33
5-30	20	46	24	21	7.0	22	1	0.33	3.0	.33

Table 6 (Continued)

SUBJECT 1		S+: P	S-: R		Intermittent Reinforcement					
Date	Session #	Total S+-S-	Total S+	Correct S+	Freq. Correct	Total S-	Errors	Freq. Err.	Time	Floor
5-31	21	40	23	15	5.0	17	1	0.33	3.0	.33
6-1	22	43	25	18	6.0	18	0	0.33	3.0	.33
6-4	23	43	20	18	6.0	23	2	0.66	3.0	.33
6-5	24	39	22	14	4.66	17	1	0.33	3.0	.33
6-6	25	42	23	19	6.33	19	0	0.33	3.0	.33

Table 7

Data Sheet

SUBJECT 2		S+: b	S-: d		Continuous Reinforcement					
Date	Session #	Total S+-S-	Total S+	Correct S+	Freq. Correct	Total S-	Errors	Freq. Err.	Time	Floor
4-30	1	78	32	31	6.2	46	15	3.0	5.0	.20
5-1	2	69	36	29	5.8	33	2	0.4	5.0	.20
5-2	3	107	55	52	10.4	52	0	0.2	5.0	.20
5-3	4	99	50	50	10.0	49	0	0.2	5.0	.20
5-4	5	93	47	47	9.4	46	0	0.2	5.0	.20
5-7	6	63	33	32	10.66	30	0	0.33	3.0	.33
5-8	7	56	28	27	9.0	28	0	0.33	3.0	.33
5-9	8	61	30	30	10.0	31	0	0.33	3.0	.33
5-10	9	57	29	29	9.66	28	0	0.33	3.0	.33
5-11	10	52	27	26	8.66	25	0	0.33	3.0	.33
5-14	11	56	28	28	9.33	28	0	0.33	3.0	.33
5-15	12	58	29	29	9.66	29	0	0.33	3.0	.33
5-16	13	54	27	27	9.0	27	0	0.33	3.0	.33
5-17	14	55	27	27	9.0	28	0	0.33	3.0	.33
5-18	15	52	26	26	8.66	26	0	0.33	3.0	.33
5-21	--	--	--	--	--	--	--	--	--	--
5-22	16	50	25	25	8.33	25	0	0.33	3.0	.33
5-23	17	51	25	25	8.33	26	1	0.33	3.0	.33
5-24	18	44	22	21	7.0	22	0	0.33	3.0	.33
5-25	19	48	24	24	8.0	24	0	0.33	3.0	.33
5-28	--	--	--	--	--	--	--	--	--	--
5-29	20	50	25	25	8.33	25	0	0.33	3.0	.33
5-30	21	42	21	21	7.0	21	0	0.33	3.0	.33

Table 7 (Continued)

SUBJECT 2 S+: b S-: d Continuous Reinforcement

Date	Session #	Total S+-S-	Total S+	Correct S+	Freq. Correct	Total S-	Errors	Freq. Err.	Time	Floor
5-31	--	--	--	--	--	--	--	--	--	--
6-1	--	--	--	--	--	--	--	--	--	--
6-4	22	42	21	18	6.0	21	0	0.33	3.0	.33
6-5	23	49	23	20	6.66	21	0	0.33	3.0	.33
6-6	24	46	23	22	7.33	23	0	0.33	3.0	.33

Table 8

Data Sheet

SUBJECT 2 S+: P S-: R Intermittent Reinforcement

Date	Session #	Total S+-S-	Total S+	Correct S+	Freq. Correct	Total S-	Errors	Freq. Err.	Time	Floor
4-30	1	79	40	40	8.0	39	1	0.2	5.0	.20
5-1	2	83	42	42	8.4	41	0	0.2	5.0	.20
5-2	3	104	52	52	10.4	52	0	0.2	5.0	.20
5-3	4	--	--	--	--	--	--	--	--	--
5-4	5	--	--	--	--	--	--	--	--	--
5-7 (.75)	6	61	31	30	10.0	30	0	0.33	3.0	.33
5-8 (.50)	7	54	27	27	9.0	27	0	0.33	3.0	.33
5-9 (.50)	8	56	29	28	9.33	27	0	0.33	3.0	.33
5-10 (.25)	9	58	29	29	9.66	29	0	0.33	3.0	.33
5-11 (.10)	10	54	27	26	8.66	27	1	0.33	3.0	.33
5-14 (.10)	11	50	25	25	8.33	25	0	0.33	3.0	.33
5-15 (.10)	12	51	25	25	8.33	26	1	0.33	3.0	.33
5-16 (.10)	13	51	25	25	8.33	26	0	0.33	3.0	.33
5-17 (.10)	14	54	26	26	8.66	28	0	0.33	3.0	.33
5-18 (.10)	15	52	26	26	8.66	26	0	0.33	3.0	.33
5-21	--	--	--	--	--	--	--	--	--	--
5-22	16	50	25	25	8.33	25	0	0.33	3.0	.33
5-23	17	45	21	19	6.33	23	1	0.33	3.0	.33
5-24	18	48	23	23	7.66	23	0	0.33	3.0	.33
5-25	19	47	24	23	7.66	23	0	0.33	3.0	.33
5-28	--	--	--	--	--	--	--	--	--	--
5-29	20	44	22	22	7.33	22	0	0.33	3.0	.33
5-30	21	50	27	23	7.66	23	0	0.33	3.0	.33

Table 8 (Continued)

SUBJECT 2		S+: P		S-: R	Intermittent Reinforcement					
Date	Session #	Total S+-S-	Total S+	Correct S+	Freq. Correct	Total S-	Errors	Freq. Err.	Time	Floor
5-31	--	--	--	--	--	--	--	--	--	--
6-1	--	--	--	--	--	--	--	--	--	--
6-4	22	44	24	17	5.66	21	0	0.33	3.0	.33
6-5	23	44	24	19	6.33	20	0	0.33	3.0	.33
6-6	24	44	22	22	7.33	22	0	0.33	3.0	.33

Table 9

Data Sheet

SUBJECT 3		S+: P	S-: R		Continuous Reinforcement					
Date	Session #	Total S+-S-	Total S+	Correct S+	Freq. Correct	Total S-	Errors	Freq. Err.	Time	Floor
4-30	1	83	41	39	7.8	42	1	0.2	5.0	.20
5-1	2	76	38	37	7.4	38	1	0.2	5.0	.20
5-2	3	100	50	50	10.0	50	0	0.2	5.0	.20
5-3	4	--	--	--	--	--	--	--	--	--
5-4	5	--	--	--	--	--	--	--	--	--
5-7	6	64	32	32	10.66	32	0	0.33	3.0	.33
5-8	7	59	30	30	10.00	29	0	0.33	3.0	.33
5-9	8	60	30	30	10.00	30	0	0.33	3.0	.33
5-10	9	59	29	29	9.66	30	0	0.33	3.0	.33
5-11	10	59	30	30	10.00	29	0	0.33	3.0	.33
5-14	11	51	26	26	8.66	25	0	0.33	3.0	.33
5-15	12	56	28	28	9.33	28	0	0.33	3.0	.33
5-16	13	55	27	27	9.00	28	0	0.33	3.0	.33
5-17	14	54	27	27	9.00	28	0	0.33	3.0	.33
5-18	15	51	25	25	8.33	26	0	0.33	3.0	.33
5-21	--	--	--	--	--	--	--	--	--	--
5-22	--	--	--	--	--	--	--	--	--	--
5-23	16	44	21	19	6.33	23	0	0.33	3.0	.33
5-24	17	43	21	21	7.00	22	0	0.33	3.0	.33
5-25	18	44	22	22	7.33	22	0	0.33	3.0	.33
5-28	19	46	23	23	7.66	23	0	0.33	3.0	.33
5-29	20	44	23	22	7.33	21	0	0.33	3.0	.33
5-30	21	50	24	24	8.00	26	0	0.33	3.0	.33

Table 9 (Continued)

SUBJECT 3		S+: P	S-: R		Continuous Reinforcement					
Date	Session #	Total S+-S-	Total S+	Correct S+	Freq. Correct	Total S-	Errors	Freq. Err.	Time	Floor
5-31	22	46	23	23	7.66	23	0	0.33	3.0	.33
6-1	23	45	23	22	7.33	22	0	0.33	3.0	.33
6-4	24	45	24	19	6.33	21	0	0.33	3.0	.33
6-5	25	46	23	23	7.66	23	0	0.33	3.0	.33
6-6	26	47	24	24	8.00	23	0	0.33	3.0	.33

Table 10

Data Sheet

SUBJECT 3		S+: b	S-: d		Intermittent Reinforcement					
Date	Session #	Total S+-S-	Total S+	Correct S+	Freq. Correct	Total S-	Errors	Freq. Err.	Time	Floor
4-30	1	79	41	34	6.8	38	4	0.8	5.0	.20
5-1	2	80	44	35	7.0	39	5	1.0	5.0	.20
5-2	3	105	52	49	9.8	53	5	1.0	5.0	.20
5-3	4	109	54	54	10.8	55	1	0.2	5.0	.20
5-4	5	92	47	47	9.2	46	0	0.2	5.0	.20
5-7 (.75)	6	58	29	29	9.66	29	0	0.33	3.0	.33
5-8 (.50)	7	59	29	28	9.33	30	1	0.33	3.0	.33
5-9 (.50)	8	60	29	29	9.66	31	1	0.33	3.0	.33
5-10(.25)	9	58	29	29	9.66	29	0	0.33	3.0	.33
5-11(.10)	10	55	28	28	9.33	27	0	0.33	3.0	.33
5-14(.10)	11	54	27	27	9.00	27	0	0.33	3.0	.33
5-15(.10)	12	50	25	25	8.33	25	0	0.33	3.0	.33
5-16(.10)	13	49	24	24	8.00	25	0	0.33	3.0	.33
5-17(.10)	14	50	25	25	8.33	25	0	0.33	3.0	.33
5-18(.10)	15	52	26	26	8.66	26	0	0.33	3.0	.33
5-21	--	--	--	--	--	--	--	--	--	--
5-22	--	--	--	--	--	--	--	--	--	--
5-23	16	50	24	24	8.00	26	1	0.33	3.0	.33
5-24	17	49	24	24	8.00	24	0	0.33	3.0	.33
5-25	18	48	24	24	8.00	24	0	0.33	3.0	.33
5-28	19	46	23	23	7.66	23	0	0.33	3.0	.33
5-29	20	48	24	23	7.66	24	0	0.33	3.0	.33
5-30	21	43	22	22	7.33	21	0	0.33	3.0	.33

Table 10 (Continued)

SUBJECT 3		S+: b	S-: d		Intermittent Reinforcement					
Date	Session #	Total S+-S-	Total S+	Correct S+	Freq. Correct	Total S-	Errors	Freq. Err.	Time	Floor
5-31	22	45	23	23	7.66	22	0	0.33	3.0	.33
6-1	23	42	21	19	6.33	21	0	0.33	3.0	.33
6-4	24	39	19	15	5.00	20	1	0.33	3.0	.33
6-5	25	42	22	20	6.66	20	0	0.33	3.0	.33
6-6	26	41	21	20	6.66	20	0	0.33	3.0	.33

Table 11

Data Sheet

SUBJECT 4		S-: P		S-: R	Continuous Reinforcement					
Date	Session #	Total S+-S-	Total S+	Correct S+	Freq. Correct	Total S-	Errors	Freq. Err.	Time	Floor
4-30	--	--	--	--	--	--	--	--	--	--
5-1	1	--	--	--	--	--	--	--	--	--
5-2	2	108	53	53	10.6	55	0	0.2	5.0	.20
5-3	3	99	49	48	9.6	50	0	0.2	5.0	.20
5-4	4	95	48	48	9.6	47	0	0.2	5.0	.20
5-7	5	64	32	32	10.66	32	1	0.33	3.0	.33
5-8	6	61	30	30	10.00	31	0	0.33	3.0	.33
5-9	7	60	30	30	10.00	30	0	0.33	3.0	.33
5-10	8	65	32	32	10.66	33	0	0.33	3.0	.33
5-11	9	62	31	31	10.33	31	0	0.33	3.0	.33
5-14	10	61	31	31	10.33	30	0	0.33	3.0	.33
5-15	11	62	31	31	10.33	31	0	0.33	3.0	.33
5-16	12	58	28	28	9.33	30	0	0.33	3.0	.33
5-17	--	--	--	--	--	--	--	--	--	--
5-18	--	--	--	--	--	--	--	--	--	--
5-21	--	--	--	--	--	--	--	--	--	--
5-22	13	59	29	29	9.66	30	0	0.33	3.0	.33
5-23	14	58	29	29	9.66	29	0	0.33	3.0	.33
5-24	15	54	26	26	8.66	28	0	0.33	3.0	.33
5-25	16	53	27	27	9.00	26	0	0.33	3.0	.33
5-28	17	47	24	23	7.66	23	0	0.33	3.0	.33
5-29	18	46	25	22	7.33	24	0	0.33	3.0	.33
5-30	19	53	26	26	8.66	27	0	0.33	3.0	.33

Table 11 (Continued)

SUBJECT 4		S-: P		S-: R	Continuous Reinforcement					
Date	Session #	Total S+-S-	Total S+	Correct S+	Freq. Correct	Total S-	Errors	Freq. Err.	Time	Floor
5-31	20	52	26	26	8.66	26	0	0.33	3.0	.33
6-1	21	51	26	23	7.66	25	0	0.33	3.0	.33
6-4	22	50	25	25	8.33	26	0	0.33	3.0	.33
6-5	23	45	24	20	6.66	21	0	0.33	3.0	.33
6-6	24	52	26	24	8.00	24	0	0.33	3.0	.33

Table 12

Data Sheet

SUBJECT 4 S+: b S-: d Intermittent Reinforcement

Date	Session #	Total S+-S-	Total S+	Correct S+	Freq. Correct	Total S-	Errors	Freq. Err.	Time	Floor
4-30	--	--	--	--	--	--	--	--	--	--
5-1	1	83	39	37	7.4	44	6	1.2	5.0	.20
5-2	2	108	51	51	10.2	57	6	1.2	5.0	.20
5-3	3	87	43	43	8.6	44	2	0.4	5.0	.20
5-4	4	87	44	44	8.8	43	0	0.2	5.0	.20
5-7 (.75)	5	57	30	26	8.66	27	0	0.33	3.0	.33
5-8 (.50)	6	56	28	28	9.33	28	0	0.33	3.0	.33
5-9 (.50)	7	58	28	28	9.33	30	2	0.66	3.0	.33
5-10(.25)	8	59	29	29	9.66	30	0	0.33	3.0	.33
5-11(.10)	9	58	30	30	10.00	28	0	0.33	3.0	.33
5-14(.10)	10	55	28	28	9.33	27	0	0.33	3.0	.33
5-15(.10)	11	50	25	25	8.33	25	0	0.33	3.0	.33
5-16(.10)	12	52	25	25	8.33	27	0	0.33	3.0	.33
5-17	--	--	--	--	--	--	--	--	--	--
5-18	--	--	--	--	--	--	--	--	--	--
5-21	--	--	--	--	--	--	--	--	--	--
5-22(.10)	13	50	25	25	8.33	25	0	0.33	3.0	.33
5-23(.10)	14	51	25	25	8.33	26	0	0.33	3.0	.33
5-24	15	53	26	26	8.66	27	0	0.33	3.0	.33
5-25	16	43	23	18	6.00	20	0	0.33	3.0	.33
5-28	17	50	26	25	8.66	24	0	0.33	3.0	.33
5-29	18	46	23	22	7.33	23	0	0.33	3.0	.33
5-30	19	49	24	24	8.00	25	0	0.33	3.0	.33

Table 12 (Continued)

SUBJECT 4		S+: b		S-: d	Intermittent Reinforcement					
Date	Session #	Total S+-S-	Total S+	Correct S+	Freq. Correct	Total S-	Errors	Freq. Err.	Time	Floor
5-31	20	48	24	21	7.00	24	2	0.66	3.0	.33
6-1	21	45	23	18	6.00	22	2	0.66	3.0	.33
6-4	22	40	20	15	5.00	20	2	0.66	3.0	.33
6-5	23	48	22	22	7.33	23	0	0.33	3.0	.33
6-6	24	50	26	24	8.00	24	0	0.33	3.0	.33

APPENDIX E

GRAPHIC DATA SUMMARIES

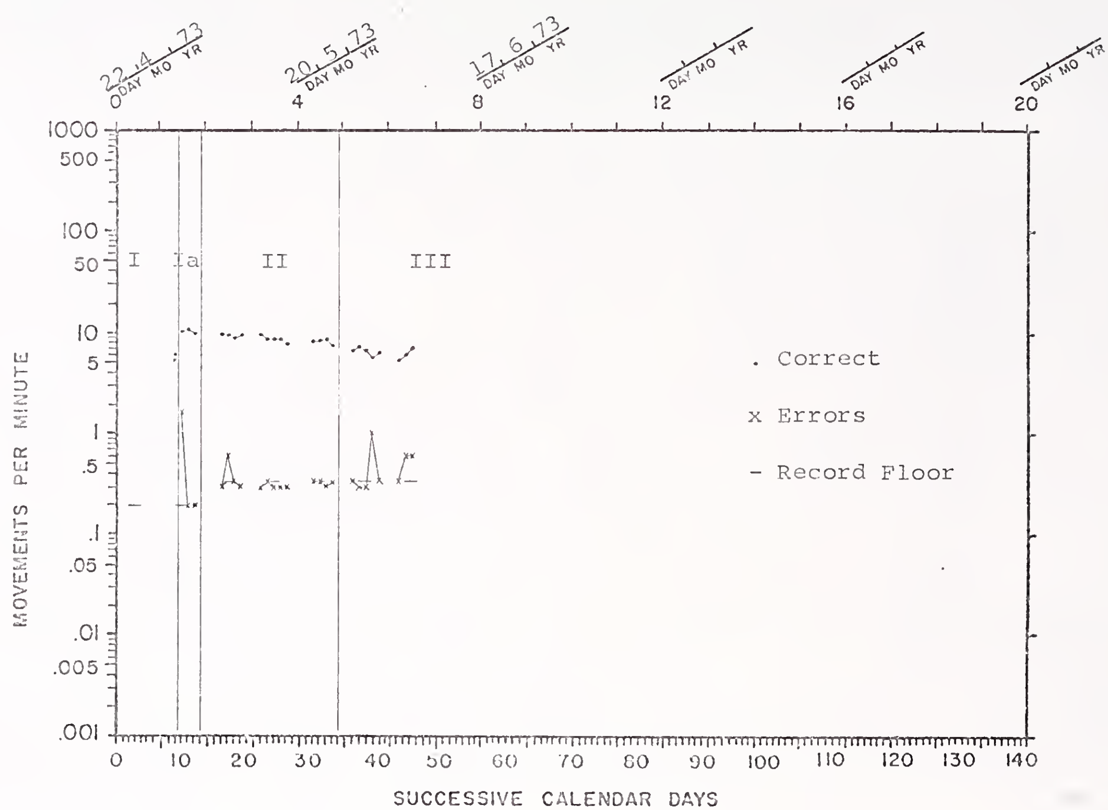


Figure 7. Subject 1: Frequency Chart, Correct and Errors, Continuous Reinforcement.

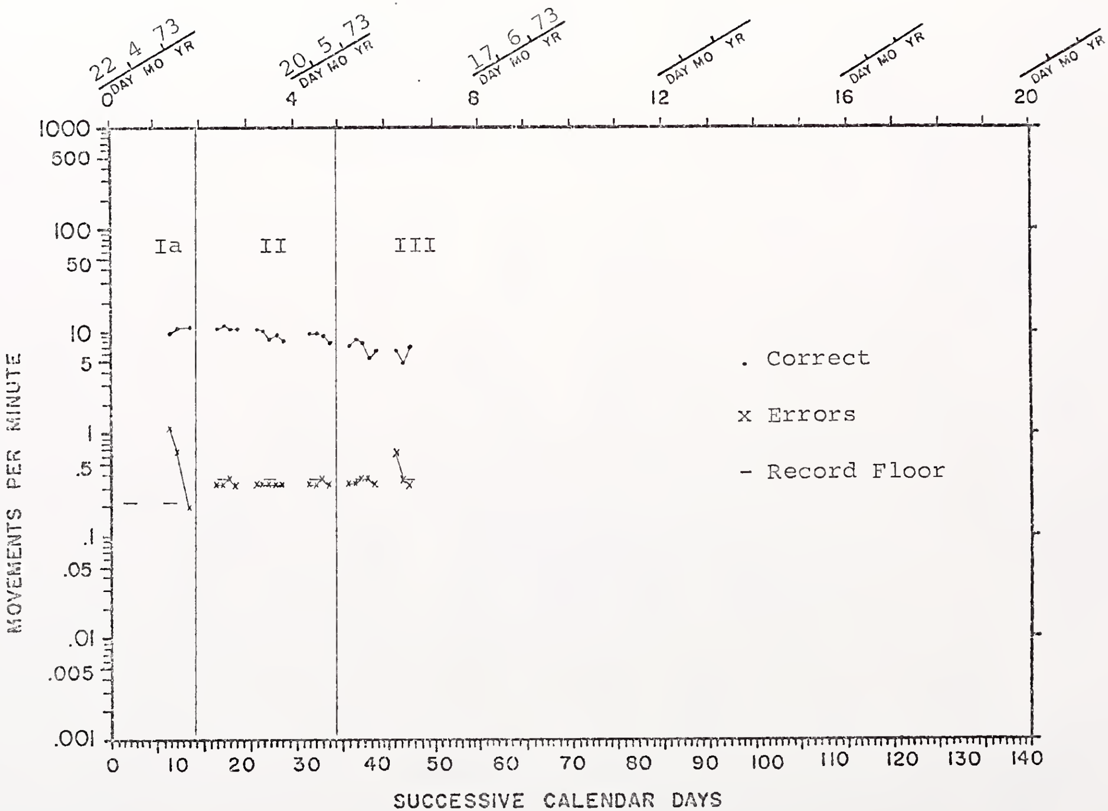


Figure 8. Subject 1: Frequency Chart, Correct and Errors, Intermittent Reinforcement.

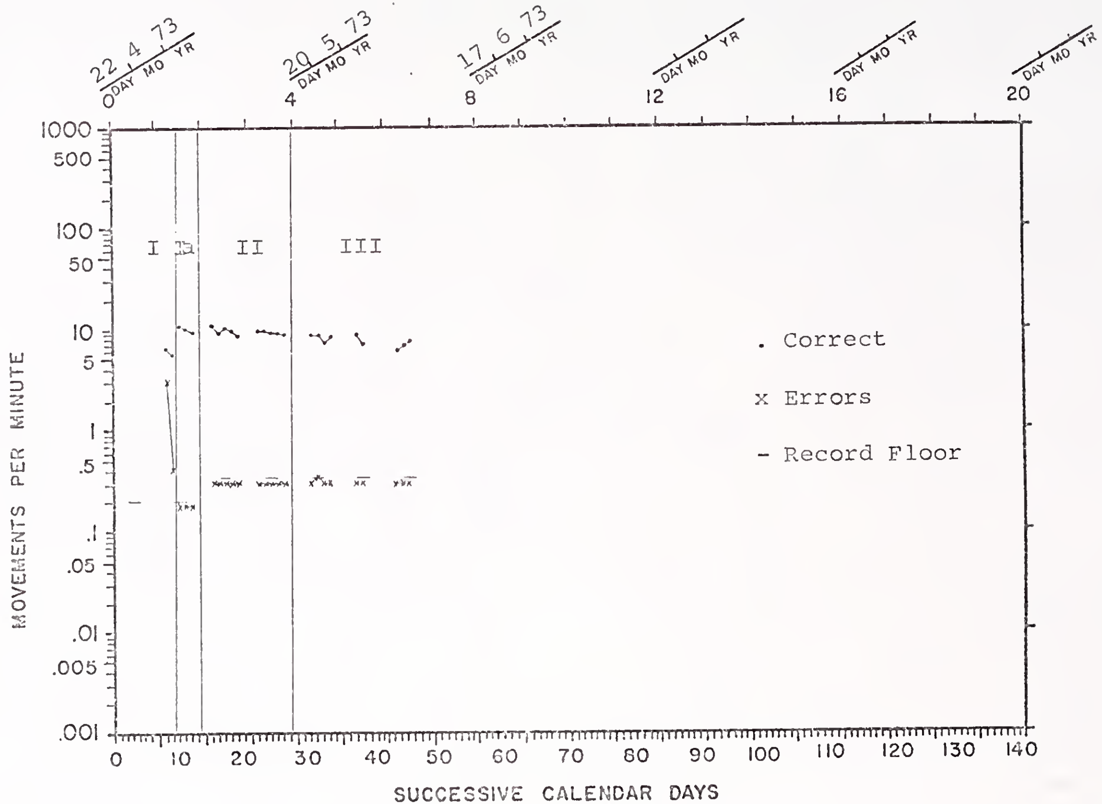


Figure 9. Subject 2: Frequency Chart, Correct and Errors, Continuous Reinforcement.

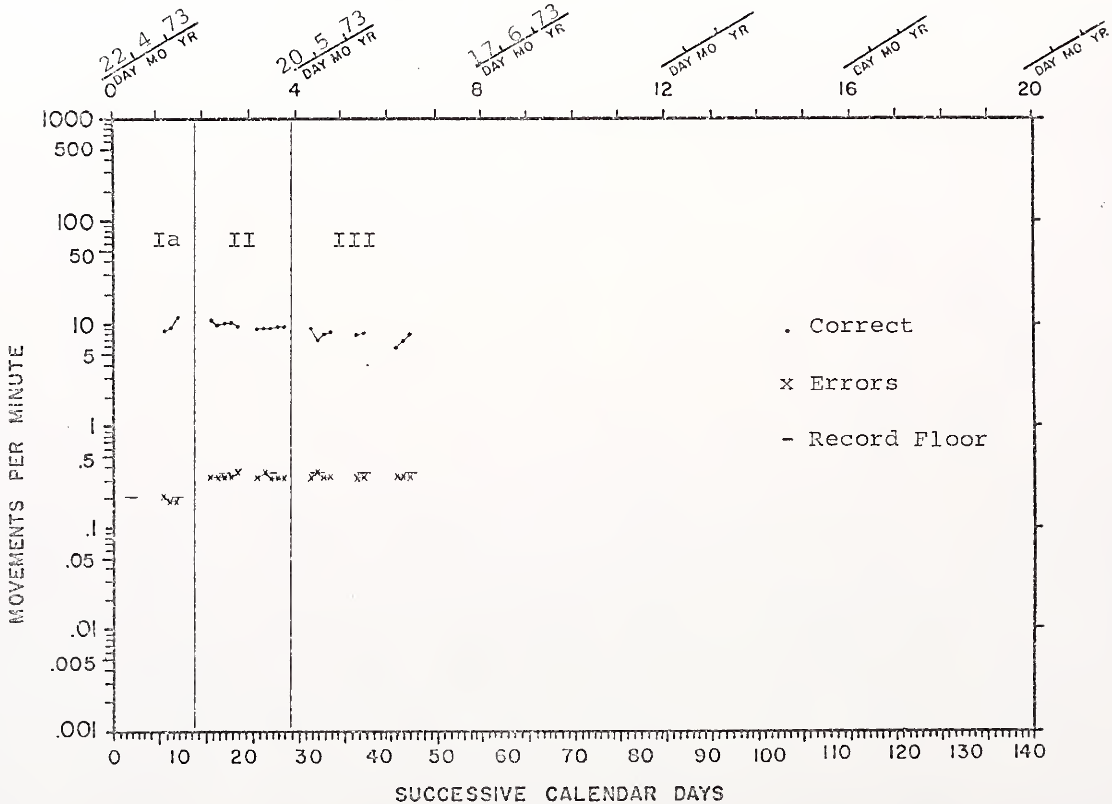


Figure 10. Subject 2: Frequency Chart, Correct and Errors, Intermittent Reinforcement.

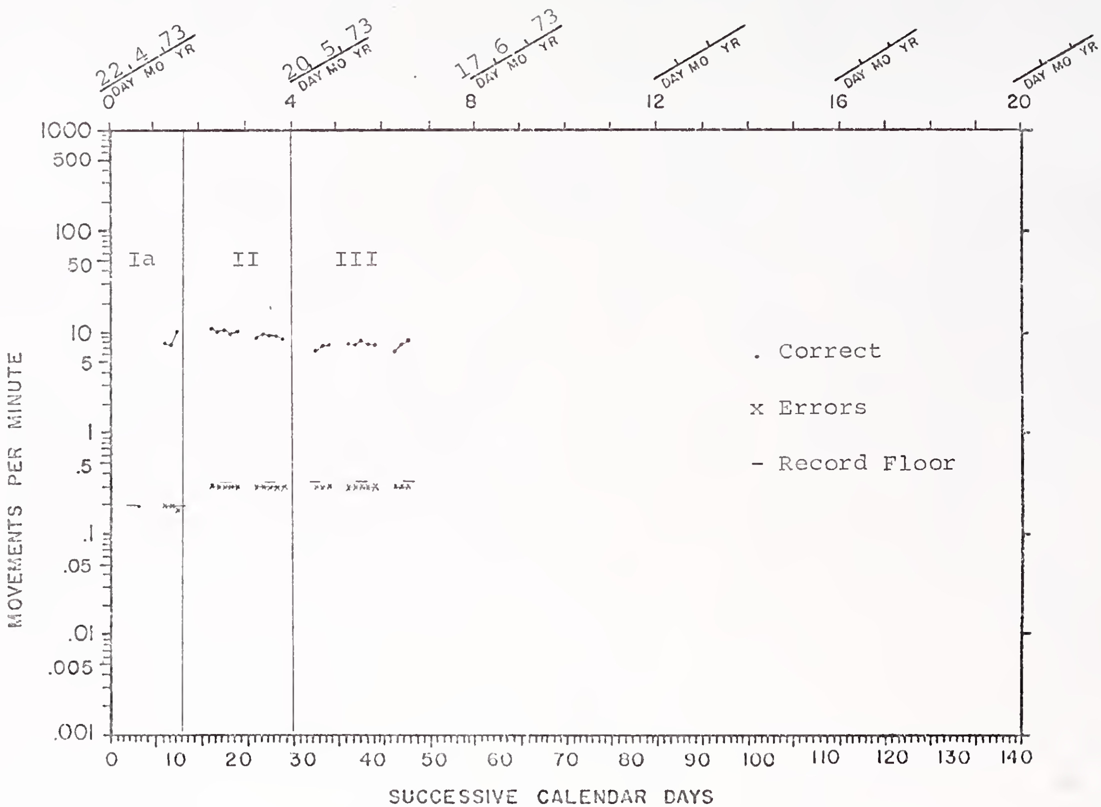


Figure 11. Subject 3: Frequency Chart, Correct and Errors, Continuous Reinforcement.

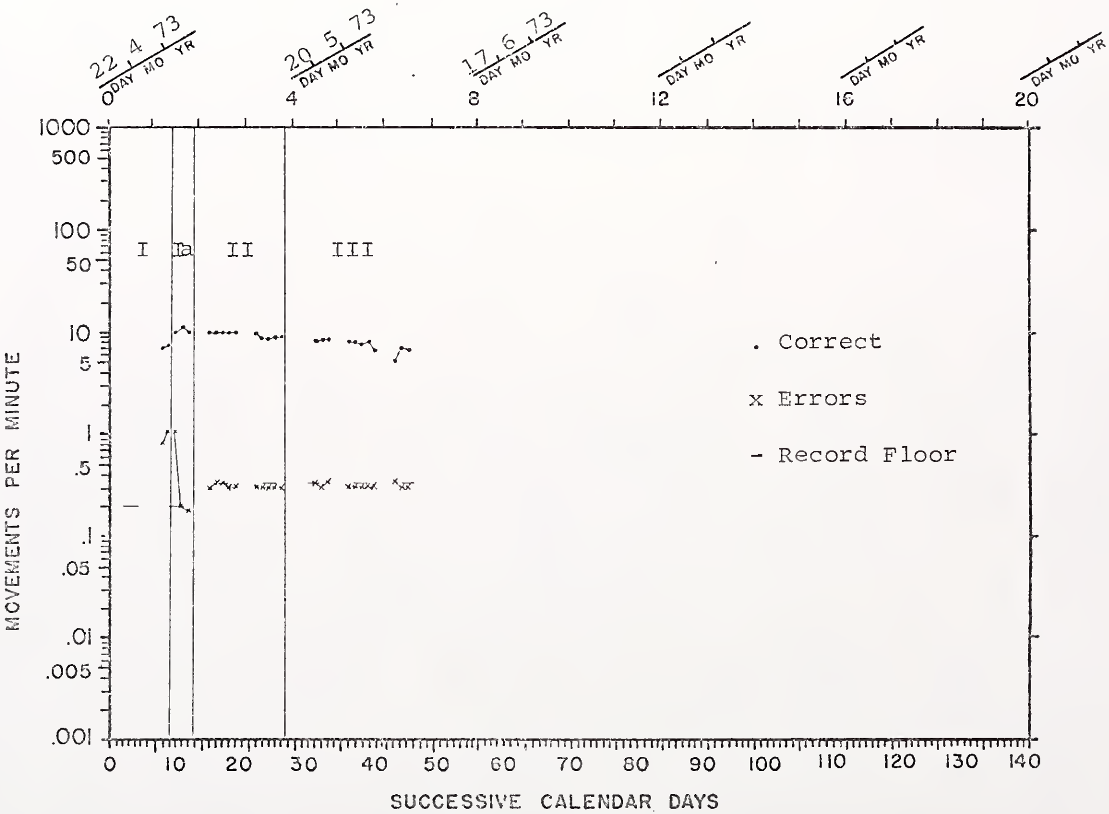


Figure 12. Subject 3. Frequency Chart, Correct and Errors, Intermittent Reinforcement.

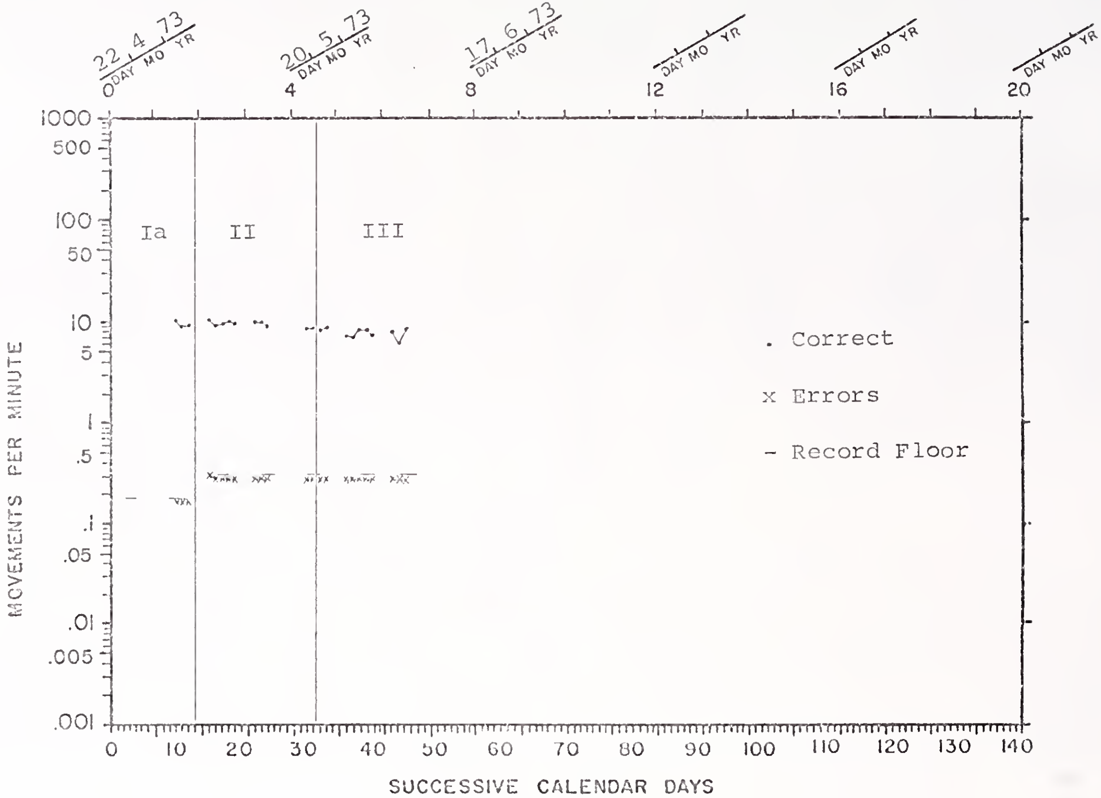


Figure 13. Subject 4: Frequency Chart, Correct and Errors, Continuous Reinforcement.

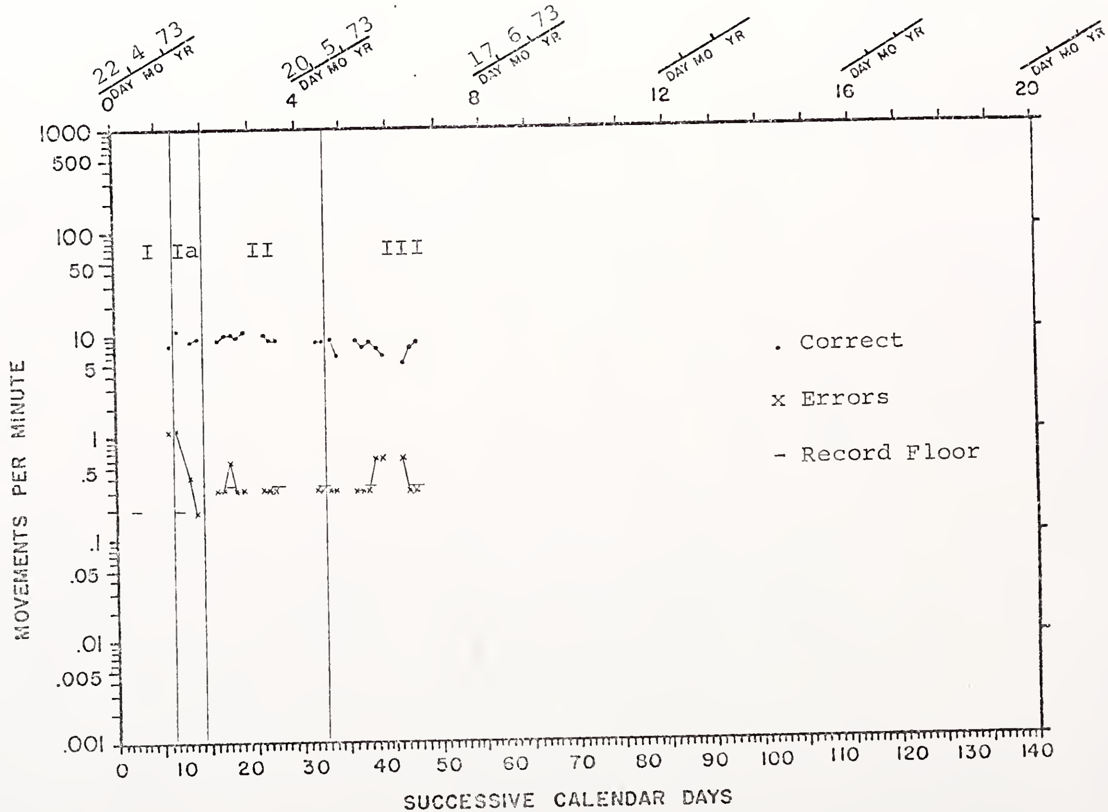


Figure 14. Subject 4: Frequency Chart, Correct and Errors, Intermittent Reinforcement.

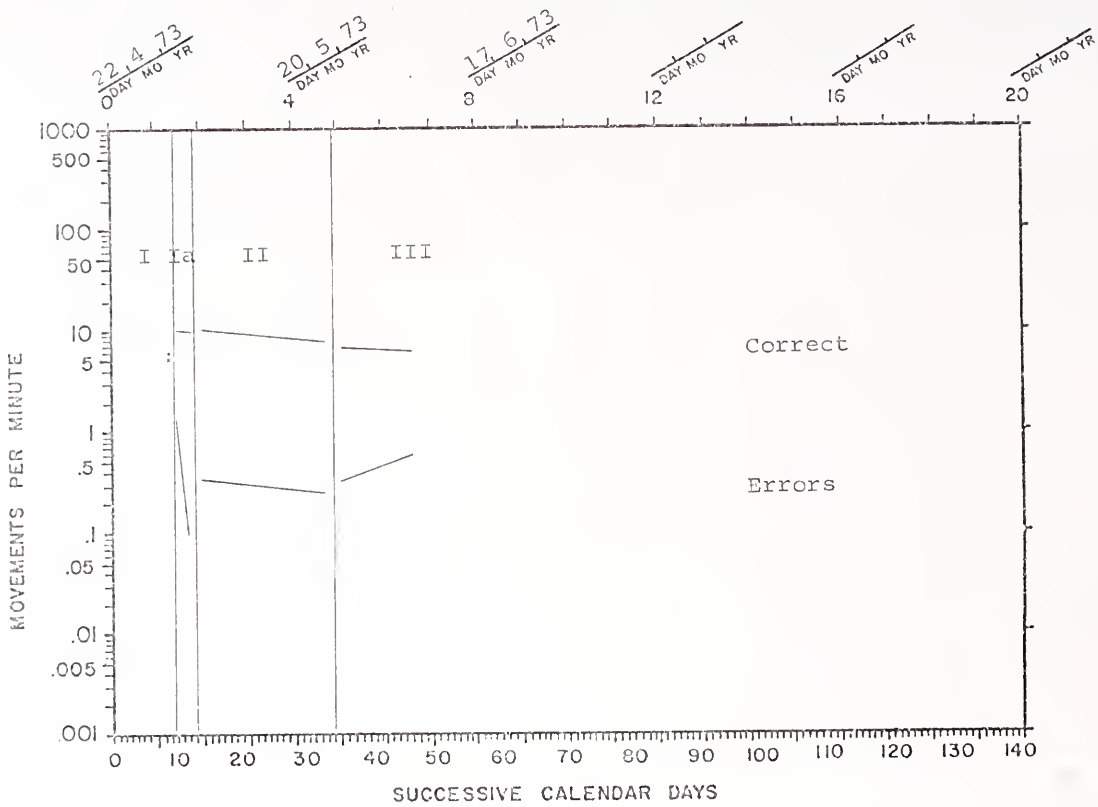


Figure 15. Subject 1: Celerations, Correct and Errors, Continuous Reinforcement.

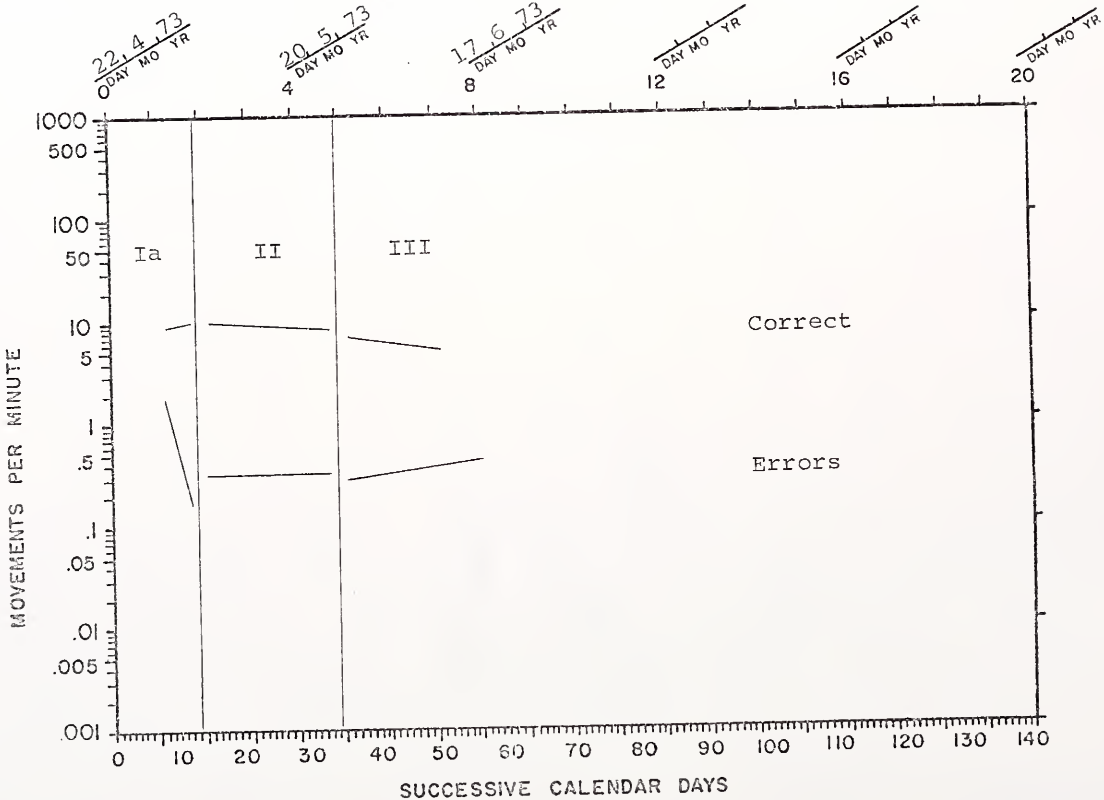


Figure 16. Subject 1: Celerations, Correct and Errors, Intermittent Reinforcement.

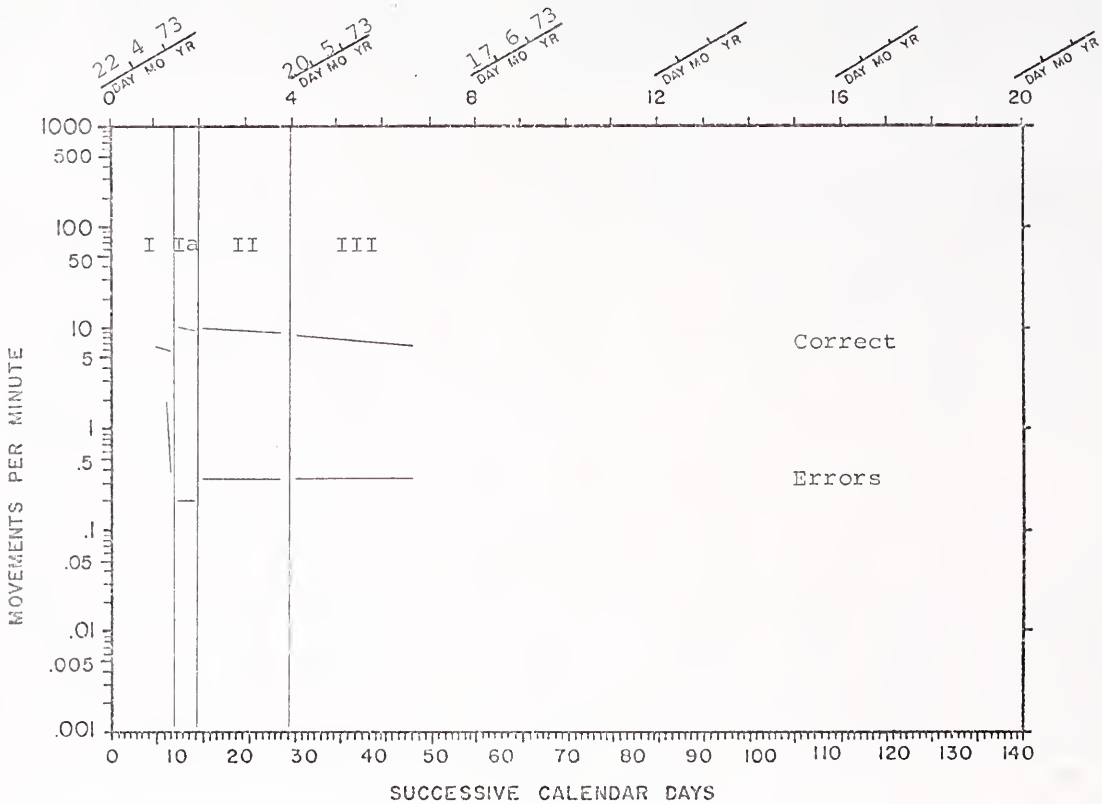


Figure 17. Subject 2: Celerations, Correct and Errors, Continuous Reinforcement.

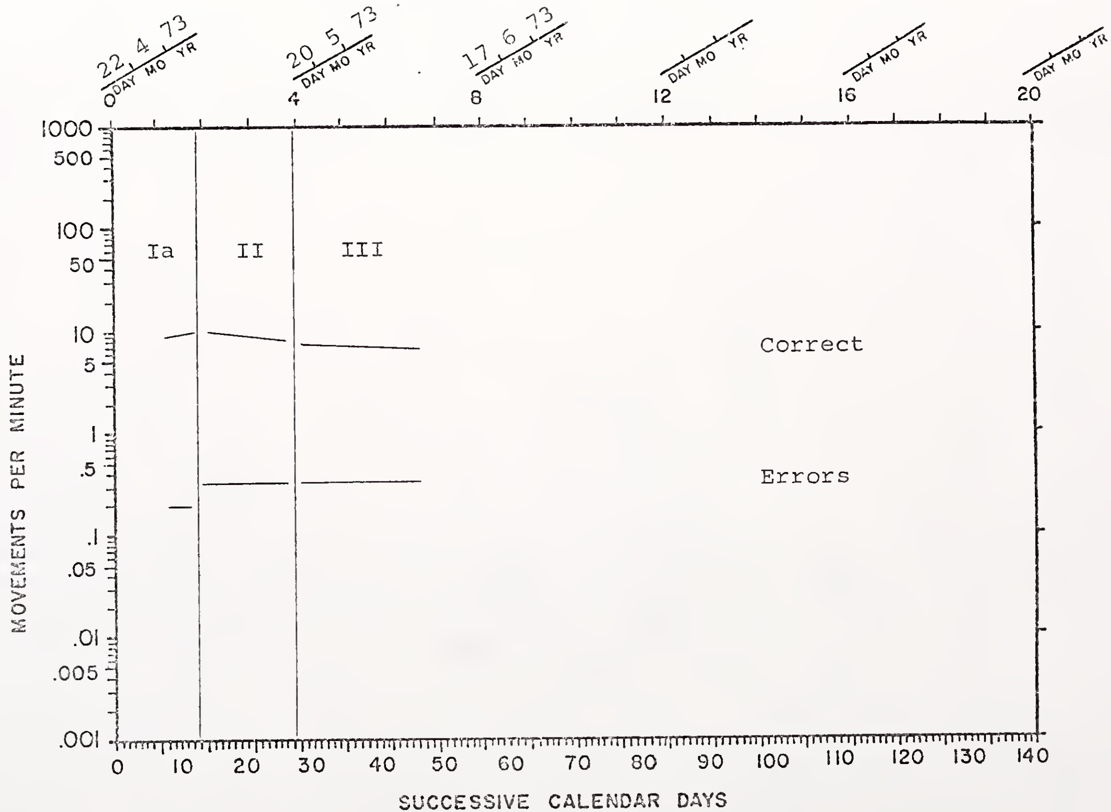


Figure 18. Subject 2: Celerations, Correct and Errors, Intermittent Reinforcement.

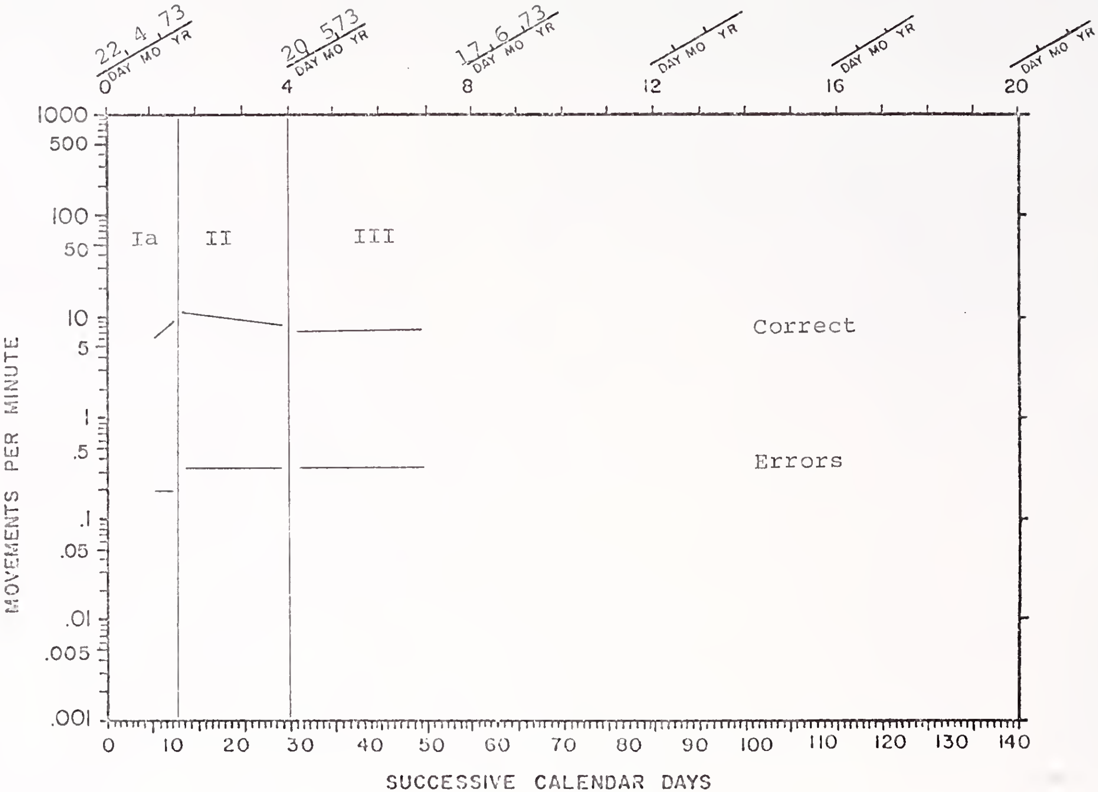


Figure 19. Subject 3: Celerations, Correct and Errors, Continuous Reinforcement.

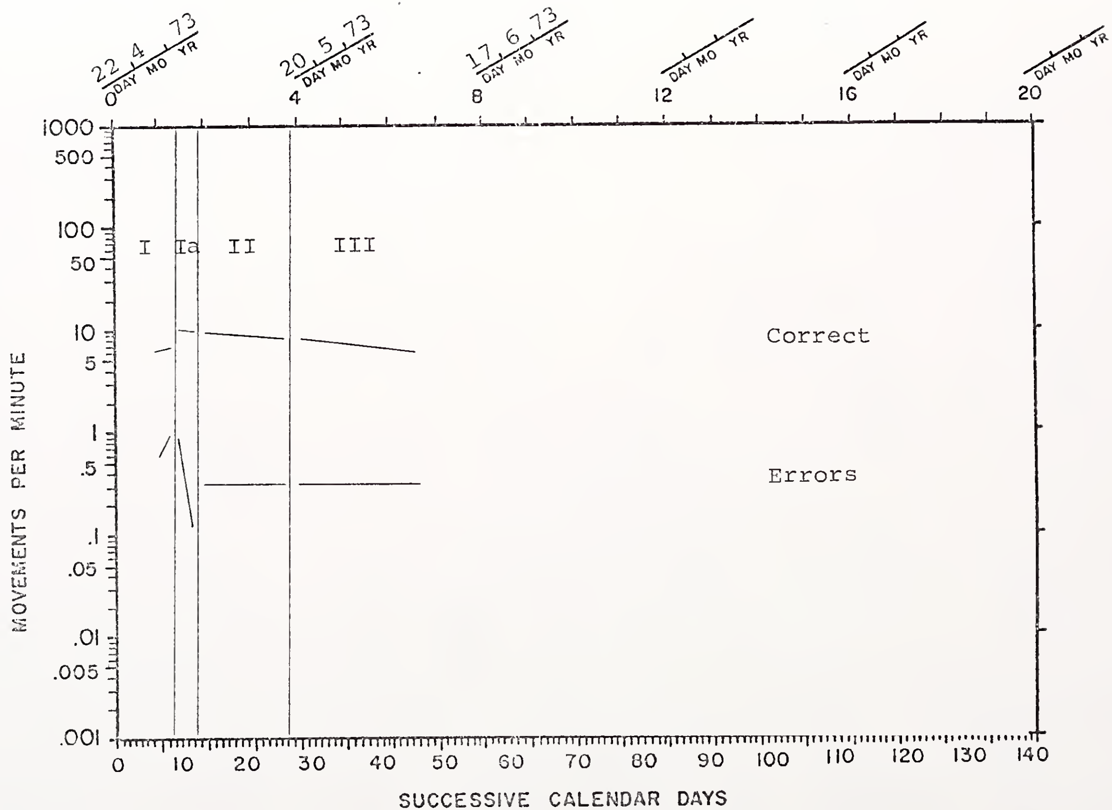


Figure 20. Subject 3: Celerations, Correct and Errors, Intermittent Reinforcement.

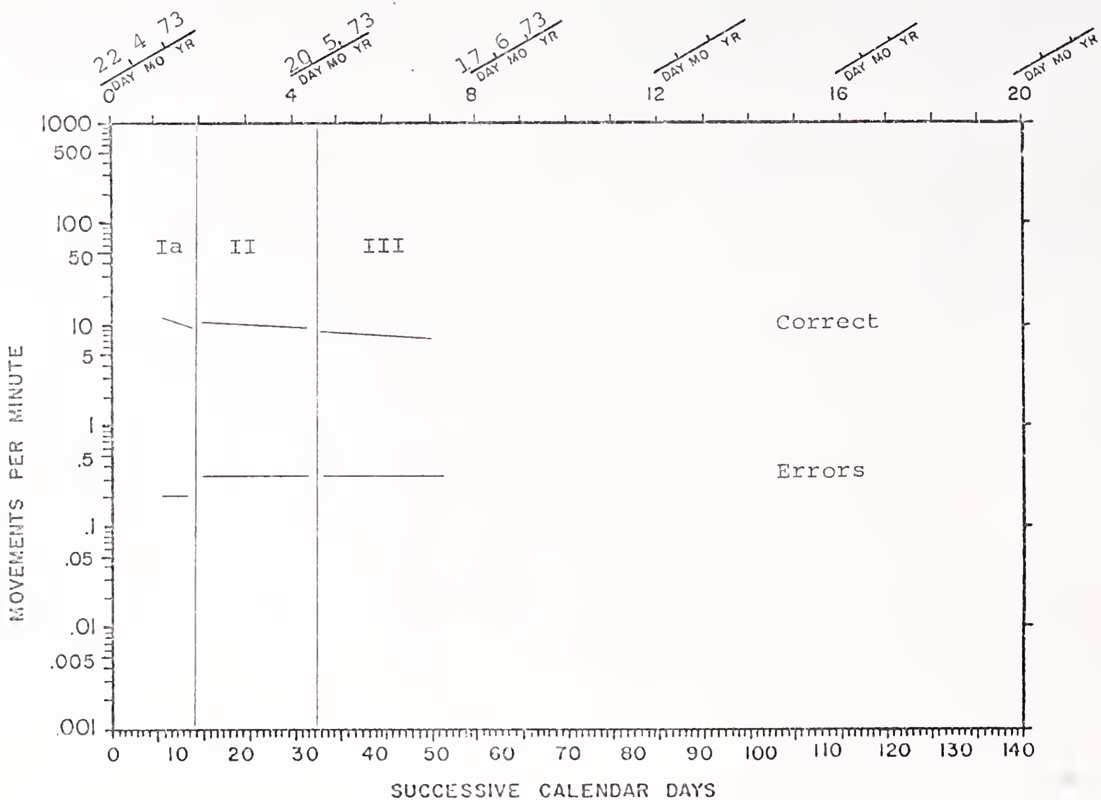


Figure 21. Subject 4: Celerations, Correct and Errors, Continuous Reinforcement.

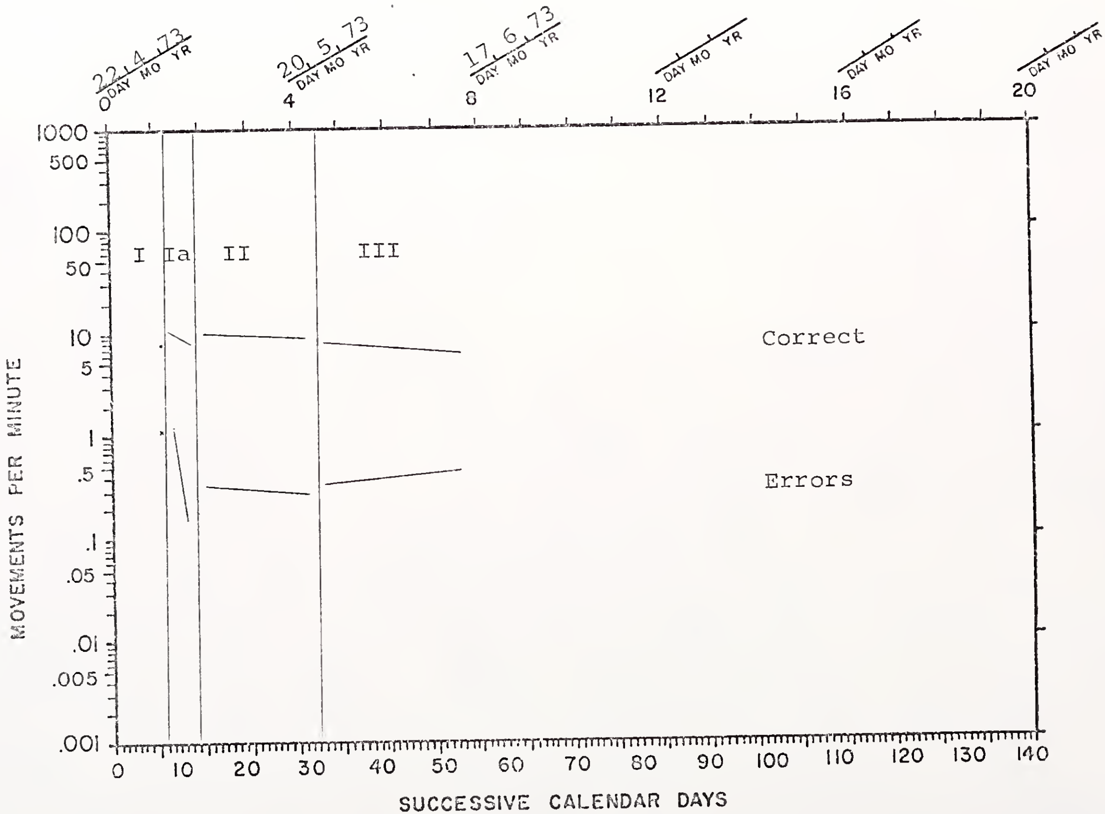


Figure 22. Subject 4: Celerations, Correct and Errors, Intermittent Reinforcement.

BIOGRAPHICAL SKETCH

John Vernon Hamby was born in Simpsonville, South Carolina, December 18, 1935. He attended Simpsonville Public Schools, graduating from Simpsonville High School in 1954. He attended Presbyterian College where he received a B.A. degree in English in 1958. Mr. Hamby returned to Simpsonville to become a teacher at Hillcrest High School, a new consolidated school in lower Greenville County. He attended Furman University on a part-time basis from 1961 to 1964, receiving a Master of Education degree in Public School Administration in August 1964. In September 1964, Mr. Hamby was appointed principal of Mauldin Elementary School of Greenville County where he remained until June 1970.

Mr. Hamby enrolled as a graduate student in the Department of Foundations of Education at the University of Florida in September 1970. While a student at the University of Florida, he served as a graduate assistant and as a teaching assistant. He received his Ph.D. degree in the psychological foundations of education in December 1973. He began work as an assistant professor in the

Elementary and Secondary Education Department of Clemson University, Clemson, South Carolina, in August 1973.

Mr. Hamby is married to the former Peggy Green Moore and they have three children: Mary Annette, Dana Elizabeth, and Lorie Louise.

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

John M. Newell

John M. Newell, Chairman
Professor of Education

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

Gordon E. Greenwood

Gordon E. Greenwood
Associate Professor of Education

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

William B. Ware

William B. Ware
Associate Professor of Education

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

Henry S. Pennypacker
Professor of Psychology

This dissertation was submitted to the Dean of the College of Education and to the Graduate Council, and was accepted as partial fulfillment of the requirements for the degree of Doctor of Philosophy.

December, 1973

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Dean, College of Education

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Dean, Graduate School